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Decoupling of Road Freight Transport and Economic Growth Trends in the UK: An Exploratory Analysis

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ABSTRACT *Between 1997 and 2004, gross domestic product increased in real terms in the UK by one-fifth, while the volume of road freight movement remained stable. This suggests that the long-awaited decoupling of economic and freight transport growth has begun, possibly leading to a new era of sustainable logistics. This paper reviews previous research on the decoupling issue and recent trends in gross domestic product/freight tonne-km elasticities in Europe and the USA. It then examines 12 possible causes of the observed decoupling in the UK using published statistics from a wide range of British and European sources. This analysis indicates that around two-thirds of the decoupling is due to three factors whose impact can be quantified: the increased penetration of the British road haulage market by foreign operators, a decline in road transport's share of the freight market, and real increases in road freight rates. Several other factors, most notably the relative growth of the service sector, the diminishing rate of centralization, and the off-shoring of manufacturing, appear to be having a significant effect, though this finding cannot be measured on the basis of available statistics. The paper concludes that, while the decoupling is in the right direction from a public policy standpoint, the net environmental benefits are likely to be quite modest.*

Introduction

The decoupling of economic and freight transport growth has become one of the holy grails of transport policy-making. It offers the prospect of growing economic prosperity without a corresponding increase in freight-related externalities. These externalities, however, are not simply a function of the demand for freight movement, typically expressed in tonne-km. They are also affected by three other factors: the modal split (e.g. the ratio of road tonne-km to total tonne-km[1]), vehicle utilization (the ratio of vehicle-km to tonne-km) and the emission level (the ratio of emissions to vehicle-km). It is possible to cut freight-related emissions per unit of gross domestic product (GDP) by reducing one or more of these ratios, even when the total volume of freight movement continues to rise. In many countries, sustainability

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initiatives have tended to focus on these ratios because the opportunities for decoupling tonne-km and GDP trends are thought to be limited. While the underlying demand for freight movement continues to grow, however, these initiatives may be "necessary but not sufficient to achieve major improvements in the environmental balance of the transport sector" (Pastowski, 1997, p. 2).

Recent experience in the UK suggests that the relationship between GDP and tonne-km may not be as enduring as often supposed. Between 1997 and 2004, GDP rose by 21% in real terms, while total tonne-km grew by only 8% (Figure 1). Tapio (2005) proposes the term 'weak decoupling' for the situation where both the transport volume (V) and GDP increase, but the elasticity value ($\%\Delta V/\%\Delta \text{GDP}$) is below 0.8. The elasticity value for 1997–2004 was only 0.37. Even more remarkable has been the divergence of road tonne-km[2] and GDP trends over this period (Figure 1). The volume of road freight movement remained virtually stable during this period of relatively high economic growth, approximating Tapio's definition of 'strong decoupling'. With every year that passes, the decoupling of these trends looks less like a temporary aberration and more like a longer-term structural change in the propensity of the British economy to generate freight movement.

The present paper summarizes the results of an exploratory analysis of the decoupling of GDP and freight transport growth trends in the UK. It views this decoupling from the perspective of the road freight sector, which accounts for two-thirds of the UK domestic freight market and thereby exerts a strong influence on the relationship between economic growth and total freight tonne-km. Changes in the modal split are considered to be one of many factors affecting the relationship between GDP and road tonne-km.

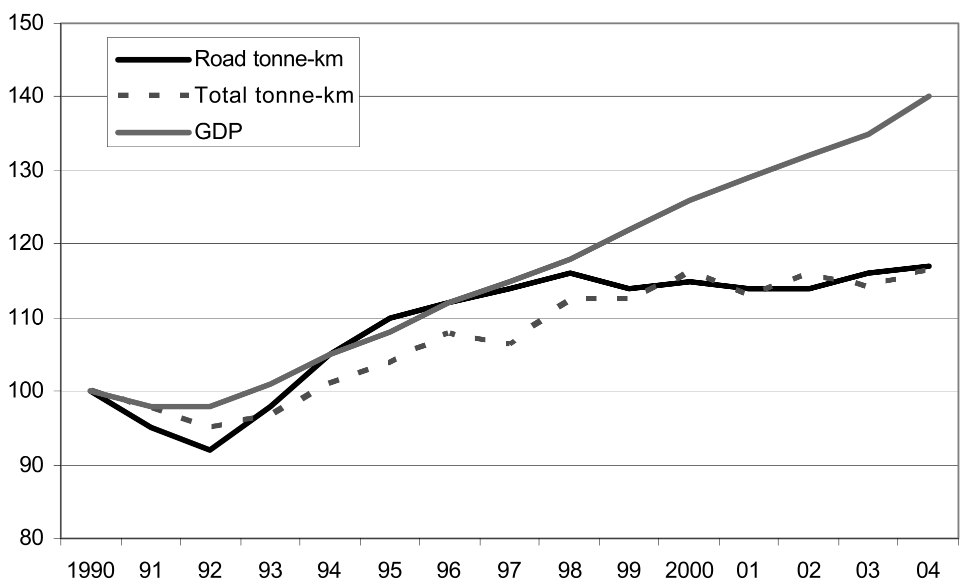

Figure 1. UK gross domestic product, tonne-km and road tonne-km trends (index 1990 = 100), 1990–2004. *Source*: Department for Transport (2005a and 2005c)

The next section puts the issue of decoupling into context by providing an historical and geographical perspective. The third section outlines the analytical framework that has been used to investigate the process of road freight growth. The fourth section examines possible causes of the observed decoupling. In the conclusion, an assessment is made of the relative importance of these causes using available quantitative and qualitative evidence.

Previous Research on the Decoupling Issue

A cross-sectional study of a sample of 33 countries at different stages of development undertaken by The World Bank using 1989 data demonstrated that the relationship between gross domestic product (GDP) and road tonne-km was extremely close (Bennathan *et al.*, 1992). Its regression analysis found that differences in GDP (with national currencies 'converted at purchasing power parities') explained 89% of the variation in road tonne-km. For the sample of 17 developed countries (including the UK), "the partial elasticity of ton-kilometres by road with respect to GDP [was] about unity (1.02)" (Bennathan *et al.*, 1992, p. 7).

Partly on the basis of international comparative data, road traffic forecasts compiled by the UK government in the 1970s assumed that road tonne-km/GDP elasticity would retain a value of 1 for the foreseeable future (Tanner, 1974). The forecasts also assumed that GDP would increase in real terms by 3% per annum 'in perpetuity' (Department of the Environment, 1975). Adams (1981) then felt at liberty to extrapolate a direct, one-to-one relationship between these variables beyond the design year of 2020 to 2212, by which time the wealth of the average British household would have reached £1 million in real terms. He envisaged life in this 'millionaire society' in which people would "spend most of their time driving around in the family juggernaut picking up piles of machine-made stuff from automatic warehouses" (Adams, 1981, pp. 205–206). The construction of this 'absurd scenario' challenged the credibility both of extrapolatory forecasting and the assumption that GDP and road freight growth trends would follow a parallel course indefinitely.

In the commentary to its 1984 forecasts, the UK government acknowledged for the first time that lorry traffic might grow at a slower rate than GDP (Department of Transport, 1985). It suggested that major drivers of road freight traffic growth in the past such as "the concentration of production and changes in the structure of retailing … had spent much of their force" (Department of Transport, 1985, p. 8) and that the decline in manufacturing's share of GDP would further decouple road freight and GDP trends. The road tonne-km/GDP elasticity was reduced, quite arbitrarily, from 1.0 to 0.7 to reflect these change. This proved erroneous, however, as the rate of road freight traffic growth actually accelerated over the next decade, causing the average elasticity value for this period to exceed 1. The growth of road freight demand did, therefore, decouple from GDP growth, but in the opposite direction to the forecasters' expectations.

A similar phenomenon occurred across the European Union (EU) during the 1990s and early 2000s. Between 1993 and 2003 the ratio of total tonne-km by inland modes to GDP in the EU-15 increased by 9% (Eurostat, 2005), providing evidence of what Tapio (2005, p. 140) calls "expansive negative decoupling". The rapid growth of freight traffic in the EU can be largely attributed to the integration of national economies into a continental trading bloc. This process was reinforced by the formation of the Single Market in 1993 when border controls were removed and international road haulage deregulated. Companies have gradually replaced nationally-based manufacturing and distribution systems with pan-European networks, often serving the whole continent from a single factory or warehouse (Bayliss and Millington, 1995). Many have also expanded the sourcing and marketing of their products beyond national borders, extending inbound and outbound supply lines. For example, between 1993 and 2003 the proportion of European chemicals sold within national markets fell from 55 to 25%, while the proportion traded internationally in the EU rose from 27 to 46% (McKinnon, 2004). The enlargement of the EU in 2004 and eastward migration of industrial capacity to the lower labour cost countries of Central and Eastern Europe is further strengthening this trend. It is expected that this restructuring of the European economy will cause road freight traffic to grow significantly faster than GDP for many years.

When the European Commission (2001, p. 15) argued in its transport White Paper that "we have to consider the option of gradually breaking the link between economic growth and transport growth", it envisaged a time when transport would grow more slowly than the economy. This policy statement did not specifically mention freight, though as Meersman and Van de Voorde (2002, p. 2) explain, "the European Commission refers primarily to freight transport when it argues that transport growth should be gradually decoupled from economic growth". As these trends have already diverged, in the opposite direction to that which the policy-makers intended, it will be an ambitious goal merely to realign them over the next decade. One study has suggested that the realignment of the GDP and road tonne-km trends will not occur until 2025 (Ecorys, 2004). Several research projects funded by the European Commission, however, have identified a series of public policy measures that could help to induce the desired decoupling. These projects include POSSUM (Banister *et al.*, 2000), SCENES (Michel Echenique and Partners Ltd, 2002a), and SPRITE (Tight *et al.*, 2004).

While the EU has been generating more tonne-km per unit of GDP, the US economy has been reducing its freight transport intensity[3] (measured by ton-miles per unit of GDP), particularly since 1980. Ton-miles per dollar of real GDP in the USA dropped by 35% between 1980 and 2002 (Bureau of Transportation Statistics, 2004). The reasons for this widely differing experience in the USA and Europe have not been fully explained. Gilbert and Nadeau (2002, p. 6) suggest that it may partly reflect "different stages in economic development". The amount of freight movement per US$ of GDP and per person are, after all, significantly higher in the USA despite two decades of decoupling. In 1998, for example, tonne-km per US$ of GDP (at purchasing power parity) and per capita were, respectively, 31 and 163% higher in the USA than in the EU (Gilbert and Nadeau, 2002). The higher per-US$ and per-capita tonne-km figures for the USA also reflect the fact that the USA has a greater land area than the EU and a more spatially integrated economy. The average length of haul for freight by all modes (excluding pipeline) was 395 km in the USA in 2002 as opposed to 183 km in the EU-15 in 2000 (Eurostat, 2003, 2004; Bureau of Transportation Statistics, 2004).

European transport policy-makers do not have to look across the Atlantic, however, to find evidence of decoupling. Between 1993 and 2003 the ratio of inland tonne-km to GDP in the UK declined by 12.7%, while it increased by 8.8% across the EU-15 as a whole (Figure 2) (Department for Transport, 2005a;

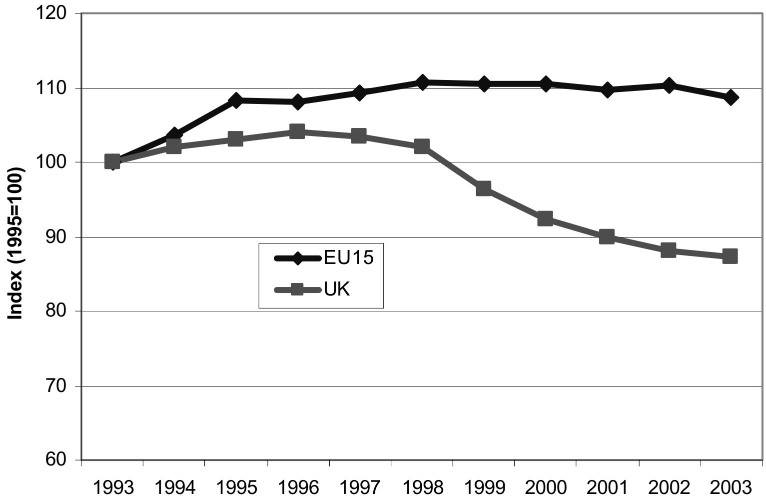

Figure 2. Ratio of tonne-km by inland transport modes to gross domestic product in EU-15 and UK. *Source*: Department of Transport (2005a) and Eurostat (2005)

Eurostat, 2005). Only Finland recorded a greater decline than the UK (of 17%). As a result of their peripherality in the EU, both the UK and Finland have escaped the huge growth in transit traffic experienced by more centrally located states. The decoupling of freight transport and GDP growth in Finland is discussed by Tapio (2005). The remainder of the present paper will focus on the decoupling observed in the UK.

Nature of Road Freight Growth

It is possible to decompose the relationship between monetary measures of economic output and road tonne-km into a series of aggregate values and key ratios, each of which can vary independently (McKinnon and Woodburn, 1996) (Figure 3). The ratio of the monetary value of GDP to the total weight of the material output of the economy will be called the gross value density. The handling factor ratio converts this physical weight of goods into freight tonnes-lifted, allowing for the fact that, as they pass through the supply chain, products are 'lifted' onto vehicles several times. For this reason, the handling factor can be considered a crude measure of the number of links in a supply chain. The average length of haul (which is the mean length of each link in the supply chain) translates the tonnes-lifted into tonne-km. Total tonne-km can be divided between different transport modes.[4] For the purposes of this paper, modal split is defined as the ratio of road tonne-km to total tonne-km.

Figure 3 compares the annual average exponential growth rates in the aggregate values and key ratios for two periods: 1985–97 and 1997–2004. These rates have been calculated by converting the original values into natural logarithms before calculating the annual average changes. This makes the percentage changes additive between the cells in Figure 3.[5] No data are available on the weight of the material output of the UK economy over these periods. One cannot, therefore, estimate changes in either the gross value density or the

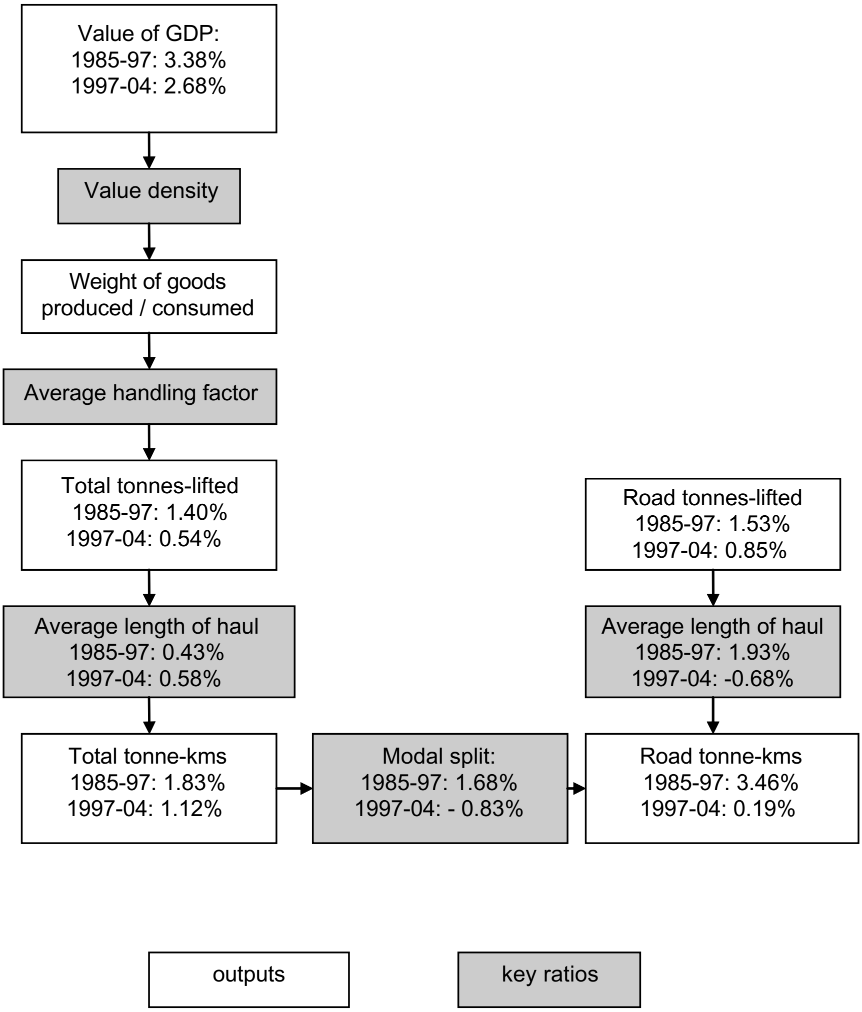

Figure 3. Average annual exponential growth rates in main output measures and key ratios. *Source:* Department for Transport (2005a)

handling factor. In the absence of this information, it is not possible to measure the extent to which the decline in the average growth rate for road tonne-km is due to a reduction in the average number of links in the supply chain or a decline in the physical quantity of products being produced and consumed.

The decline in the average rate of road tonne-km growth from 4.3% over 1985–97 to 0.3% for the more recent period appears to have been much more strongly affected by the reversal of the previously upward trends in average length of haul and road's share of total tonne-km. The magnitude of these breaks in long-established trends and the speed with which they have occurred suggest that road freight demand in the UK has undergone a fundamental change in recent years. The next section examines the possible causes of this change.

Possible Reasons for the Observed Decoupling

On the basis of a priori reasoning and informal discussions with freight transport specialists in the UK government, industry, academic institutions, and consultancy companies, 12 possible causes of the GDP/road-freight decoupling have been identified. It has been possible to obtain statistical data to assess the relative effect of some of these causes. Attention has focused on any evidence of trends in other explanatory variables exhibiting 'trend-breaks' in recent years. Some possible causes must remain hypothetical at this stage as insufficient data are available to measure their impact on the observed decoupling. Figure 4 maps the relationships between 11 of the 12 possible causes and the key economic and freight transport parameters identified within the analytical framework. The first of the possible causes, which is excluded from this diagram, relates to the consistency of statistical evidence on the various parameters.

1. Change in the Systems of Statistical Accounting

From time to time, governments change the methods they use to survey economic and transport variables. Had such changes occurred since 1997, they could have distorted the relationship between GDP and road tonne-km. According to government officials responsible for the two main statistical series, no changes have been made to the methodology of either survey over the

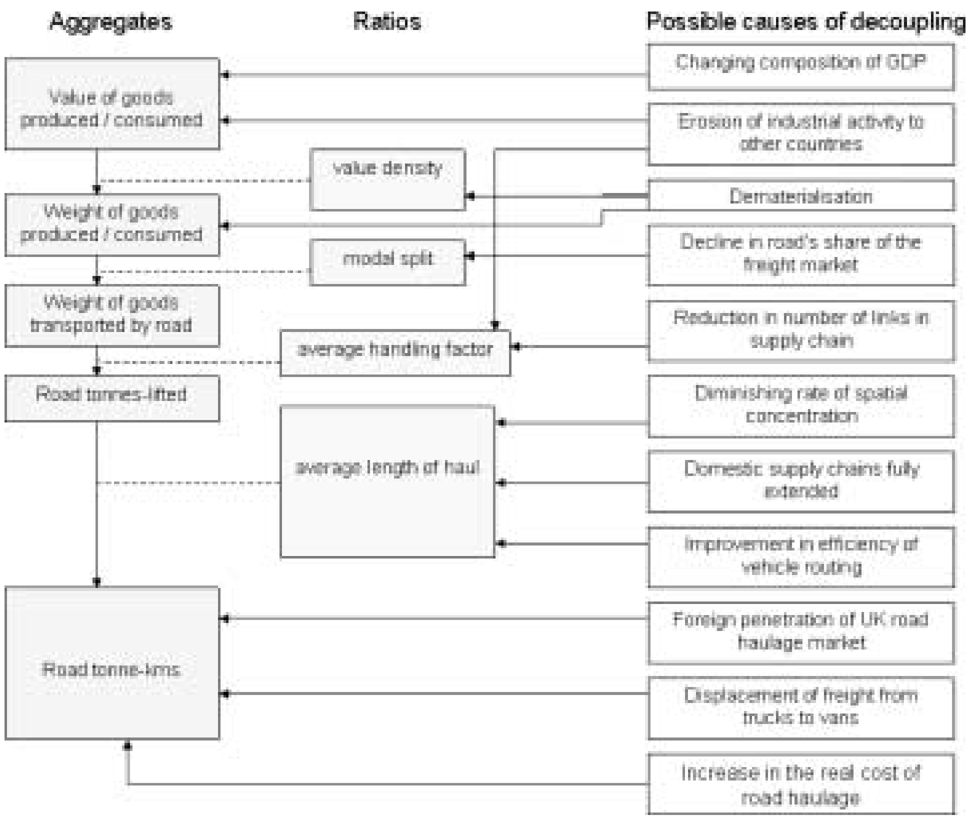

Figure 4. Relationships between freight transport parameters and possible causes of decoupling

period in question which would have affected the consistency of the time series data.[6]

2. Dematerialization

Schleicher-Tappeser *et al.* (1998, p. 4) define dematerialization as a "reduction of material resources required per unit of GDP". It can result from the weight of goods in the economy declining, their value increasing or a combination of these trends.

Weight of goods in the economy. Eurostat (2002) calculates several measures of the weight of goods in EU economies. The most appropriate for the purposes of the present paper is domestic material consumption (DMC). This is calculated as follows:

$$DMC = DE + IM - EM,$$

where DE is the total weight of all materials extracted from within a country for domestic use, IM is the total weight of imported materials, and EM is the total weight of exported materials. It is essentially a measure of the total weight of materials consumed within a country. As almost all of these materials must be transported, it is likely that there will be some correlation between DMC and freight tonne-km. A decline in DMC over a period when the economy is expanding could, therefore, induce some decoupling of tonne-km and GDP. Several processes have been reducing DMC, such as the miniaturization of products, the replacement of heavier materials (e.g. metal or wood) by lighter ones (e.g. plastic), the switch in electricity generation from coal to natural gas, and the digital transmission of information- and entertainment-related products that were previously transported in physical form. Others, such as shortening product life cycles,[7] the growth of packaging and a decrease in average household size, have had the opposite effect (Schleicher-Tappeser *et al.*, 1998).

According to Eurostat (2002, p. 41), the UK experienced "absolute dematerialization" over 1980–2000, when the DMC rate declined by 1%. Over the same period, GDP rose in real terms by 63.8%. As no comparative DMC data are available for 1997–2004 and earlier periods, it is not known if the rate of dematerialization has accelerated since the late 1990s. It seems likely, however, that dematerialization will have had a minor effect on decoupling for two reasons. First, the rate of long-term dematerialization in the UK appears to have been relatively slow, whereas the decoupling since 1997 has been quite pronounced. Second, as Niederl *et al.* (2003) acknowledge in an analysis of the links between dematerialization and freight transport in Austria, the volume of freight movement can be influenced more by changes in the structure of the "production–consumption chain" (p. 47) than by variations in the physical mass of material flowing through the economy. The structure of the supply chain is discussed more fully under heading numbers 7–11 below.

Value of goods. As GDP is measured by monetary value and freight movement by the weight of goods moved, any increase in the average (real) value of these goods per tonne will cause a divergence of GDP and road tonne-km trends. Value densities have been subject to conflicting pressures. Several processes have been pushing them upwards, such as the development of new, more technically sophisticated products, the increased processing and refrigeration of food products, and the absorption of more value-added services into the selling price of the product. Miniaturization and material substitution have had a similar effect. Meanwhile, the price of many products has been declining in real terms as a consequence of improved productivity, market liberalization, economies of scale, access to cheaper raw materials and/or global sourcing. The relative strength of these processes varies both from sector to sector and through time. This is reflected in the differing trends in value density observed at a sectoral level in the UK between 1985 and 1995[8] (Campbell and McKinnon, 1998) (Table 1). Mean value density increased only marginally over this period. One must exercise caution in interpreting these values, however, as they are based on international trade statistics. An analysis of Danish data by Fosgerau and Kveiborg (2004, p. 4) revealed that "imputed value density values from trade flows… induces unacceptably large errors". The same study, however, also found that over most of the period examined (1981–92) the average value density of freight was stable and exerted little influence on the freight transport–GDP relationship.

The issue is not whether value densities have, on average, been rising or falling, but rather whether the longer-term trend has undergone a marked change in the UK since the late 1990s. On the basis of available evidence this seems unlikely, though it is a subject that requires further investigation.

Overall, it is likely that dematerialization has had only a minor impact on decoupling over the period since 1997.

3. Change in the Composition of Gross Domestic Product

Some sectors of the economy generate more road tonne-km per £1 billion of output than others. It is generally believed that those sectors that produce and distribute tangible goods (manufacturing, agriculture, construction and utility

Table 1. Average value densities (£ per tonne), 1985–95

	1985	1990	1995	Percentage change, 1985–95
Wood and pulp	143	161	197	38
Machinery	6768	8805	8532	26
Transport equipment	3659	5419	4524	24
Chemicals and fertiliser	790	767	965	22
Other manufactured articles	1415	1879	1589	12
Textiles and cloth	4171	4105	3986	–4
Agricultural products	283	244	267	–5
Food and drink	1181	1058	1014	–14
Metals and metal ores	428	384	362	–15
Building materials (including cement)	2655	1951	1686	–37
Coal and coke	53	32	31	–42
Other crude minerals	50	40	29	–43
Petrol and petroleum products	176	74	55	–69
Mean	1675	1917	1787	7

Source: Campbell and McKinnon (1998).

sectors) have a much higher freight transport intensity than the service sector. This cannot be empirically substantiated as it is not possible to differentiate road freight movements associated with service and non-service activities.[9] It is, nevertheless, widely accepted that "it is not so much growth of GDP that is the driving force behind freight transport, but the increase in industrial output" (Meersman and Van de Voorde, 2002, p. 5).

If one accepts that service activities generate fewer road tonne-km relative to sales revenue than non-service activities, the relative growth of the service sector could contribute to the decoupling of GDP and road tonne-km trends. The UK economy, like that of most other developed economies, has been undergoing a long-term structural change, with services expanding their share of total GDP. This trend has markedly accelerated since 1997. After a period of relative stability, when the service sector share remained at around 66–67% of GDP, it rose from 67 to 73% between 1997 and 2003 (Figure 5). The relative growth of services is likely, therefore, to have been partly responsible for the decoupling, though its effect cannot be quantified.

Decoupling could also result from restructuring within the production and manufacturing sectors. Industrial sectors, after all, vary in the amount of road freight movement they generate per unit of output. Ideally, for the purposes of this analysis, the restructuring should be measured by changes in the weight of goods produced by each sector. In their study of decoupling in Denmark, Fosgerau and Kveiborg (2004) had access to such data and concluded that "changes in the commodity mix [were] relatively unimportant" in explaining the decoupling of GDP and freight transport trends. In the absence of similar data for the UK, disaggregated road tonne-km statistics were used to assess changes in the relative proportions of different types of commodity carried in 1997 and 2004 (Figure 6). Only modest changes were detected, suggesting that, over the period

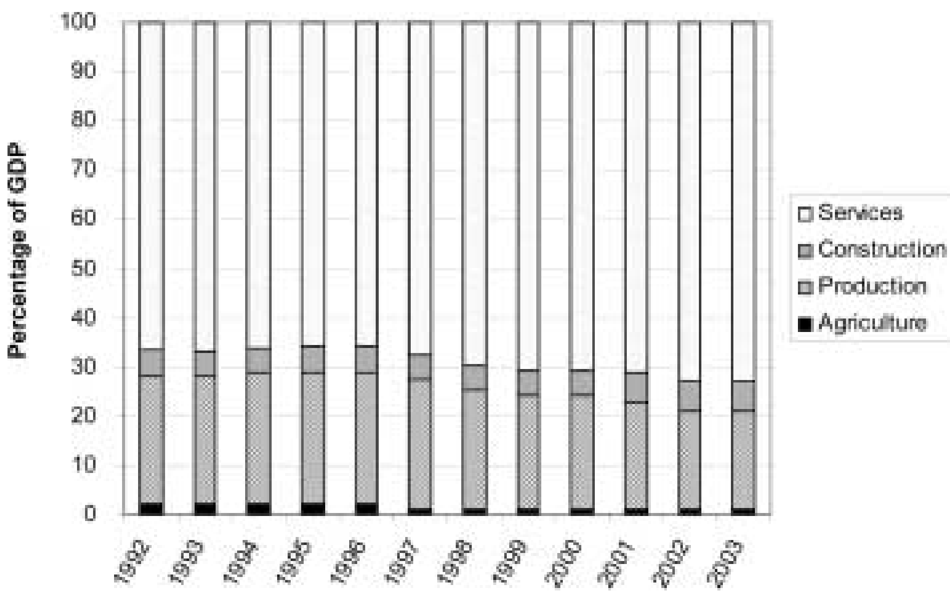

Figure 5. Changing composition of gross domestic product, 1992–2003. *Source*: Office of National Statistics (2005d)

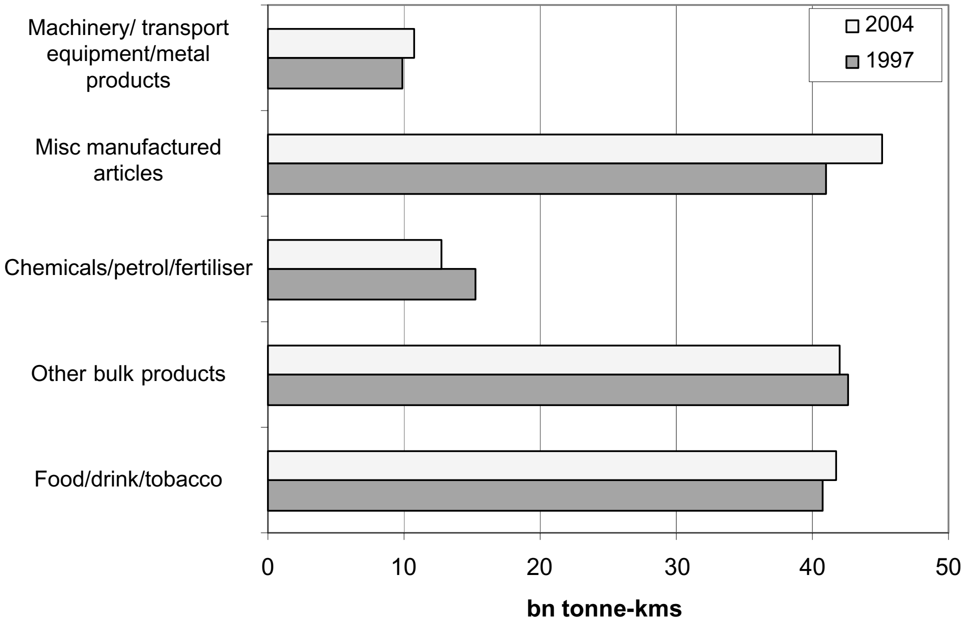

Figure 6. Composition of road tonne-km by commodity group. *Source*: Department for Transport (2005c)

in question, industrial restructuring is likely to have had relatively little impact on decoupling.

4. Decline in Road's Share of the Freight Market

Mode-specific decoupling can be caused by changes in the freight modal split. Verny (2003) calls this 'relative decoupling' to distinguish it from 'absolute decoupling' resulting from a change in the total demand for freight transport.

The year 1997 marked a watershed in the development of the British freight market. Up to that year, road had been increasing its share of total tonne-km (Figure 7). Some of the long-term growth in road tonne-km had therefore been attributable to an increase in freight market share. Between 1997 and 2004, road's share of total tonne-km declined from 67.4 to 62.7% (Department for Transport, 2005a). This break in the earlier trend was partly associated with the privatization of railfreight services in 1996. Between 1997 and 2004, rail increased its share of the freight market from 7 to 8%. The share of the market held by water-based services increased by a greater margin, from 21 to 24%. The additional 4.6 billion tonne-km moved by these other modes represented 22% of the extra 20.7 billion tonne-km that would have been carried by truck had road tonne-km grown in line with GDP over this period. A shift in the modal split from road to other modes was therefore a contributory factor, being responsible for roughly one-fifth of the decoupling.

5. Increase in the Penetration of the UK Road Haulage Market by Foreign Operators

Over the past decade there has been a sharp increase in the proportion of foreign-registered trucks entering the UK. In 1997, foreign operators

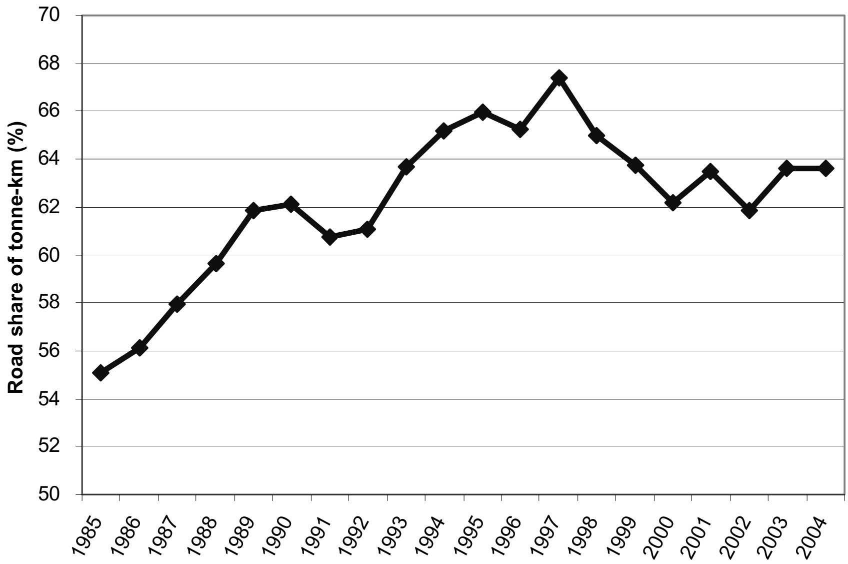

Figure 7. Percentage of total tonne-km moved by road, 1985–2004. *Source*: Department for Transport (2005a)

accounted for 52% of the trucks arriving at UK ports. By 2004 this proportion had risen to 75% (Department for Transport, 2005b) (Figure 8). This trend is significant because foreign-registered vehicles are not covered by the Continuing Survey of Road Goods Transport (CSRGT), the official source of domestic road tonne-km data for the UK.[10] Freight movement by foreign vehicles on British roads is, therefore, excluded from the road tonne-km statistic.

The net effect of this trend on road tonne-km figures over 1997–2004 is difficult to establish. The activities of foreign trucks in the UK have only been surveyed twice: in 2000 and 2003. The former survey (Department of the Environment, Transport and the Regions, 2000) was relatively small (1019 trucks), had limited scope and was confined to a single location. In 2003 a much larger sample of foreign vehicles (2109) was surveyed at most of the main roll on–roll off (ro-ro) ports and terminals, and data were collected on a much broader range of variables (Department for Transport, 2003a). This was the first survey to estimate the amount of freight movement handled by foreign operators on the UK legs of international movements. Although no similar data are available for earlier years, it is possible to derive estimates on the assumption that the number of tonne-km carried by foreign operators directly corresponds to the number of foreign-registered trucks entering the UK. This suggests that foreign lorries may have captured around 5 billion tonne-km of freight movement on the UK legs of international hauls between 1997 and 2003. Confirmation that there has been a major transfer of tonne-km from UK-registered vehicles to foreign vehicles over this period can be found in the results of the International Road Haulage Survey (Department for Transport, 2004a). They show that in an expanding market for international road freight services, total tonne-km carried by British international hauliers (both in the UK and other European countries) declined by 28% between 1997 and 2003. The IRHS does not enquire about the

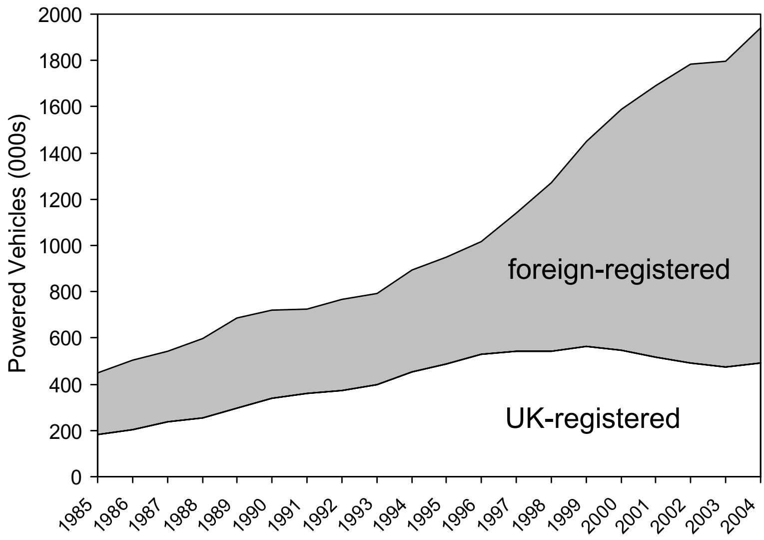

Figure 8. Numbers of trucks travelling between the UK and mainland Europe, 1985–2004. *Source*: Department for Transport (2005b)

tonne-km carried by UK-registered hauliers on the UK legs of international journeys, though does differentiate vehicle-km driven in the UK from those run in other countries. If one assumes that tonne-km are split in similar proportions to vehicle-km, road tonne-km carried by British international hauliers would have declined by 1.4 billion between 1997 and 2003. This means that in 2003 foreign hauliers were effectively carrying all the growth in international road freight movement to and from the UK over this period plus 28% of the tonne-km that British hauliers carried on the UK legs of international journeys in 1997.

Allowance must also be made for the growth of cabotage over this period. Cabotage is the term given to the domestic movement of freight by foreign-registered vehicles. Available survey data suggest that there was a sharp increase in cabotage penetration of the UK road haulage market between 1997 and 2003. The extent of this increase is uncertain, however, because of statistical disparities. Table 2 shows the cabotage penetration rates[11] estimated by Eurostat and the UK government between 1997 and 2003 using different survey methodologies. The British estimates are substantially lower, though still show a steep increase in cabotage between 2000 and 2003. For the purposes of this analysis, the Eurostat figures will be used as they are based on a larger sample of operators and provide a more consistent time-series. This suggests that the amount of freight movement on cabotage journeys within the UK increased from 79 million tonne-km in 1997, the year preceding full liberalization of cabotage, to 1.61 billion tonne-km in 2003.

By adding the growth in tonne-km moved by foreign vehicles on the UK legs of international hauls to the growth in cabotage tonne-km, it is possible to assess the contribution to road freight–GDP decoupling made by the increased penetration of the UK haulage market by foreign operators. It indicates that this trend was responsible for around 33% of the decoupling.

Table 2. Estimates of road cabotage penetration rates for the UK

	Eurostat	UK government
1997	0.05	–
1999	0.48	–
2000	0.87	0.06
2001	0.86	–
2002	0.96	–
2003	1.05	0.4

Sources: Department of the Environment, Transport and the Regions (2000), Allen (2001), Department for Transport (2003a), Oberhausen (2003), Sciullo and Smihily (2005).

6. Displacement of Freight from Trucks to Vans

The road tonne-km trend that has been correlated with economic growth relates solely to freight movement in trucks with gross weights in excess of 3.5 tonnes (typically described as heavy goods vehicles, or HGVs). Freight moved in vans lighter than 3.5 tonnes is excluded from the analysis. The main reason for this exclusion is that until recently very little data were collected in the UK on the activities of small vans. Only two government surveys of small van traffic have compiled tonne-km statistics, in 1992–93 and 2004 (Department of Transport, 1993; Department for Transport, 2004b).

There are good reasons for hypothesizing that some of the decoupling of HGV tonne-km and GDP trends has been due to a downward displacement of freight onto the small van fleet. The widespread adoption of just-in-time (JIT) replenishment has had the effect of reducing consignment sizes and increasing the frequency of delivery. This will have made it more economical for some companies to substitute vans with gross weights of less than 3.5 tonnes for larger and heavier rigid vehicles. Some of the growth in van traffic has been attributed to the spread of JIT (Michel Echenique and Partners Ltd, 2002b).

The growth of van traffic, expressed in terms of vehicle-km, has outstripped that of HGVs. Between 1985 and 2004 the ratio of van-km to truck-km has risen fairly steadily from 1.46:1 to 2.07:1 (Figure 9). Much of the growth in van-km has been associated with the general expansion of the service sector and use of vans to carry equipment and employees rather than freight. The amount of freight movement handled by vans has, nevertheless, increased both in absolute and relative terms over the past decade. It rose from 5.9 billion tonne-km (4.2% of all road tonne-km) in 1993 to 10.7 billion tonne-km in 2004 (6.6% of road tonne-km).

This increase in vans' share of road tonne-km does not in itself constitute evidence that the growth of van traffic has contributed to the observed decoupling. Much of the growth in tonne-km in this sector of the freight market may, after all, be newly generated and not simply displaced from heavier vehicles. For example, the growth of online shopping, which has been particularly pronounced in the UK (Omwando *et al.*, 2004; Verdict, 2005), has effectively added extra links to supply chains which traditionally terminated at shops. The transfer of responsibility for home delivery from the consumer to the retailer (or carrier working on its behalf) has substituted commercial vehicle movements for car trips and, to a lesser extent, public transport journeys. The movement of retail purchases in cars,

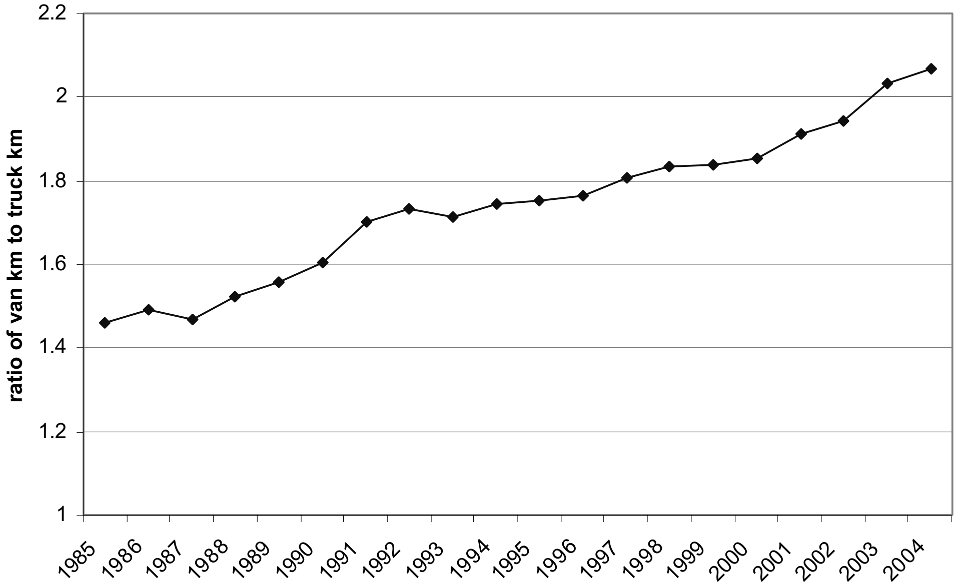

Figure 9. Ratio of van-km to truck-km, 1985–2004. *Source*: Department for Transport (2005a)

buses, and trains is a form of latent freight movement that has never appeared in official freight transport statistics. The growth of home delivery by commercial vehicles should have increased its statistical 'visibility' and, all things being equal, resulted in an increase in the road tonne-km figure. However, as much of this growth has been handled by vans, for which freight statistics are very limited, it has not featured in analyses of macro-level freight trends. Nor is it likely to have significantly distorted the relationship between HGV tonne-km and GDP.

The fact that the ratio of van-km to truck-km has increased in a linear fashion since 1985 and there has not been any obvious discontinuity in the trend since 1997 suggests that displacement of freight from trucks to vans is unlikely to have been a major cause of decoupling. This assumes, however, that there has been a close correlation between the total distance vans travel and the tonne-km of freight they carry.

7. Reduction in the Average Number of Links in the Supply Chain

The tonne-km statistic is determined both by the average number of links in the supply chain and their average length. The focus here is on the number of links; developments causing changes in their average length of haul are discussed under later headings.

As explained above, the average number of links in a supply chain can be crudely measured by the handling factor. Decreasing handling factors contributed to a modest decoupling of GDP and tonne-km in Denmark over 1981–92 (Kveiborg and Fosgerau, 2004). Handling factor values were calculated in the UK for 12 commodity classes for 1985, 1990 and 1995 (Campbell and McKinnon, 1998). When averaged across these commodity classes, the handling factor rose by 7% between 1985 and 1990 and showed no change between 1990 and 1995.[12] Individual commodity classes, however, were subject to widely varying handling

Table 3. Handling factor values for industrial sectors, 1985, 1990 and 1995

	1985	1990	1995
Coal and coke	100	110	67
Textiles and cloth	100	97	76
Metals and metal ores	100	88	81
Chemicals and fertiliser	100	94	94
Agricultural products	100	99	98
Other crude minerals	100	102	99
Other manufactured articles	100	121	110
Food and drink	100	113	123
Building materials (including cement)	100	101	123
Petrol and petroleum products	100	103	125
Machinery	100	122	130
Transport equipment	100	130	161
	100	107	107

Source: Campbell and McKinnon (1998).

factor trends over this period (Table 3). Some, most notably transport equipment, machinery and food, exhibited a steep increase in average handling factor. In the case of transport equipment and machinery this may be attributed to the vertical disintegration of the manufacturing process as a result of the outsourcing of non-core processes to subcontractors (NEI *et al.*, 1999). In the grocery sector it could be partly related to the growth of food processing and refrigeration, the insertion of a primary consolidation stage in the retail supply chain and increase in the cross-shipment of products within the distribution networks of supermarket chains (Aujla *et al.*, 2004). On the other hand, bulk, primary products, such as coal, coke and metals, experienced a substantial reduction in handling factors indicating a rationalization of their supply chains. The similar trend observed for textiles and clothing may be associated with increased import penetration, as discussed under heading 11 below.

No attempts have been made to calculate handling factors for the period since 1995. The variability of sector-level trends in handling factors in the recent past makes it difficult to speculate about changes in the average number of supply chain links over the past decade. Changes in this variable were not a major cause of the growth in road freight movement between 1985 and 1995. It is possible, however, that they have had a significant impact on decoupling since then. This will require further investigation.

8. Diminishing Rate of Spatial Concentration

The spatial concentration of economic activity has traditionally been one of the main drivers of road freight growth. It is thought to have been responsible for much of the increase in the average length of haul that occurred during the 1970s, 1980s and 1990s in the UK (McKinnon, 1989a; McKinnon and Woodburn, 1996). Table 4 outlines several of the major forms of concentration that occurred in the UK over the past 30 years.

The process of spatial concentration is now at an advanced stage and cannot continue indefinitely. Eventually, production and distribution systems will become fully centralized or multiple facilities will reach their maximum economic

Table 4. Examples of economic activities experiencing spatial concentration

Primary production	The extraction of various raw materials, particularly coal, aggregates, clay and limestone, has become concentrated in a smaller number of larger mines and quarries, partly for economic reasons, but also because of the exhaustion of supplies at some sites
Manufacturing	Companies have exploited economies of scale by concentrating production capacity in fewer, larger plants. In some cases, this has resulted in a net reduction in the number of factories, while in other cases, it has involved retaining the same number of factories, but increasing the degree of plant specialization. Such 'focused factory' strategies have been widely adopted in several industrial sectors (Christopher, 2005)
Stockholding	The centralization of inventory offers several important benefits. In accordance with the 'square-root law', companies can reduce the amount of inventory they need to hold to maintain a given level of customer service (Maister, 1976). They can also enjoy economies of scale in warehousing, mix product ranges more easily and control the distribution function more tightly (McKinnon, 1989b)
Sortation	Parcel carriers and pallet-load companies have centralized sorting operations in large 'hubs' where handling operations can be highly mechanized. There has been a steep growth in the volume of road freight being moved through these hub-and-spoke networks, mainly as a result of just-in-time replenishment, forcing down the average order size and the growth of direct delivery to the home. Routing orders through these hubs, many of which are clustered in the English Midlands, makes their movement more circuitous and has the effect of increasing tonne-km per tonne delivered
International freight handling	An increasing proportion of international freight has been channelled through a smaller number of ports and airports. These terminals have expanded their hinterlands and, in the case of major hubs such as the ports of Southampton and Dover and Heathrow Airport, effectively serve the whole country. This concentration of terminal capacity has yielded economies of scale and scope and given shippers access to a broader range of transport services
Waste management	Landfill capacity in the UK has become concentrated in a smaller number of larger sites. Between 1994 and 2005, the number of sites fell from 3400 to 2200, while the quantity of waste buried in landfills remained fairly stable at around 100 million tonnes per annum (Environment Agency, 2005)

size. The process may also be slowed, arrested or possibly reversed by increasing congestion on the road network. Much of the concentration that occurred in the 1970s–1990s was associated with the construction of the motorway network. By increasing the average speed and reliability of transport operations, road development allowed companies to serve wider areas within daily delivery restrictions (Quarmby, 1989). They could then alter the trade-offs they made between transport and other logistical costs to reduce the optimum number of facilities required to supply their market areas. In recent years, however, the average length and variance of road transit times have increased as traffic congestion has worsened. It has been estimated by a traffic information company, whose bridge-mounted sensors continuously monitor vehicle flows, that between 1998 and 2002 the level of congestion on the UK motorway network rose by around 16% (Trafficmaster, 2002). Both government and industry anticipate significant deterioration of traffic conditions on much of the trunk road network over the next decade (Department for Transport, 2003b; British Chamber of Commerce, 2004). The introduction of the Road Transport Directive[13] in April 2005 and stricter timetabling of deliveries to commercial premises has imposed further constraints on the scheduling of truck fleets. These developments are discouraging companies from further centralizing their distribution operations and causing some to consider increasing rather then reducing depot numbers (NAI Fuller Peiser, 2005).

There are strong grounds for believing that the spatial concentration of economic activity is weakening. It is nevertheless difficult to test this hypothesis empirically. Until the early 1990s it was possible to use establishment-related data collected in the Census of Production to measure the degree of concentration at a sectoral level. This Census has since been superseded by the annual Prodcom survey which collects information solely at an enterprise level (Office of National Statistics, 2005a). The only macro-level data that can now be used to assess the degree of spatial concentration is that held on the government's Inter-departmental Business Register. This records information about employment and sales in 'local units', disaggregated by the Standard Industrial Classification (SIC) and district (Office of National Statistics, 2005b). No information is given about the nature of the activities performed at these sites. Although classified as manufacturing related, many of these sites are likely to be small sales offices or repair centres. Indeed, roughly two-thirds of the local units classified in the manufacturing category have fewer than five employees. An analysis has been conducted of units with 20 or more employees as these are more likely to be engaged in production, storage and/or distribution. The analysis found wide inter-sectoral variation and suggested that, overall, there has been a small degree of concentration over 1998–2003 (Table 5). The total number of local manufacturing sites with 20 or more employees declined by 6.6%, while the total amount of gross value added rose by 2%. During the 1980s the spatial concentration of manufacturing output was much more pronounced, particularly among larger firms (McKinnon and Woodburn, 1993).

A weakening of centralizing pressures within the UK economy would be consistent with the stabilization of the average length of haul for road freight between 1998 and 2003. Over this period, the average length of haul actually declined by an average of 0.1% per annum in contrast to the fairly steady 2.0–2.5% annual increase in this variable over the previous 20 years (Department for Transport, 2005c). In 2004 the average length of haul dropped by 5.2% in a single year.

Changes in the average length of haul are not only the result of centralization/decentralization. They can also be caused by two other processes, both of which are also difficult to quantify:

- Changes in the efficiency of vehicle routing.[14]
- Expansion/contraction of companies' supply chain links upstream to suppliers and downstream to customers, i.e. the sourcing and marketing of products over larger/smaller areas.

These two potential causes of decoupling are discussed below.

9. Improvement in the Efficiency of Vehicle Routing

This efficiency can be measured with respect either to the shortest road distance or to the straight 'as-the-crow-flies' distance. The latter measure would be relevant if, over the period in question, there had been a significant increase in the

Table 5. Percentage changes in the numbers of local manufacturing units and mean gross value added (GVA) by unit, 1998–2003

Standard Industrial Classification (SIC)		Percentage change 1998–2003 Mean GVA/site	Number of local units
23	Coke, refined petroleum products, nuclear fuel	68	–29
18	Wearing apparel, dressing, dyeing, fur	–6	–49
19	Leather and leather products	–14	–52
21	Pulp, paper and paper products	23	–13
30	Office machinery and computers	3	–23
33	Medical precision, optical instrument, clocks	21	–4
24	Chemicals, chemical products, man-made fibres	16	–7
26	Other non-metallic mineral products	11	–11
15/16	Food products, beverages and tobacco	19	–1
35	Other transport equipment	16	–1
27	Basic metals	0	–16
20	Wood and wood products	14	9
17	Textiles and textile products	–24	–29
29	Machinery and equipment not elsewhere classified	–8	–11
22	Publishing, printing, recorded media	1	2
28	Fabricated metal products, excluding machinery	–5	1
36/37	Manufacturing not elsewhere classified	–5	2
31	Electrical machinery and apparatus not elsewhere classified	–10	0
25	Rubber and plastic products	–8	5
34	Motor vehicles, trailers and semi-trailers	–23	5
32	Radio, television and communication equipment	–44	–2
	All sectors	3	–7

Source: Office of National Statistics (2005b).

density of the UK road network, allowing trucks to travel more directly between collection and delivery points. In fact, over the past decade investment in UK road infrastructure has been at an historically low level. The total length of classified road increased by only 0.7% between 1997 and 2003 and motorway kilometres by only 3.0% (Department for Transport, 2005a). It is possible, however, that the efficiency with which vehicles are routed across the existing road network is improving. This would have the effect of reducing tonne-km relative to the weight and value of products carried.

Over the past decade there has been a marked increase in the application of computerized vehicle routing and scheduling (CVRS) packages. The real cost of CVRS has declined while the quality and user-friendliness of the software has improved. Company case studies suggest that the use of CVRS can cut vehicle-km by between 5 and 10%, with the magnitude of the reductions determined by the nature of the delivery operation and standard of the previous system of manual routing (Department for Transport, 2005d).

The impact of the adoption of CVRS on the trend in total road tonne-km is likely to have been moderated by two factors, however. First, CVRS systems are generally designed to minimize transit time and/or delivery cost, rather than distance travelled. Given the structure of road transport cost functions, it is often more important to minimize time-related costs than distance-related costs. Second, in an effort to avoid congested sections of road, many trucks are following more circuitous routes. Telematics systems are making it easier to reroute vehicles around bottlenecks dynamically. This can cut both average transit times and their variability, but at the expense of increasing trip lengths and tonne-km.

No statistics are available to assess the net effect of CVRS implementation on the road tonne-km trend, though it seems likely that it will have made a minor contribution, if any, to the observed decoupling of this trend from economic growth.

10. Domestic Supply Chains Becoming Fully Extended

The wider sourcing of supplies and expansion of market areas have been intrinsic features of economic development in the UK, and other countries, for centuries. As transport and communication networks have improved, companies have extended their 'logistical reach' to find better, cheaper, and more diverse sources of supply and sell their products to more distant customers. This process is currently very active at both European and global scales (A. T. Kearney Ltd, 2004). It is possible, however, that it has begun to slacken at a national scale as domestic supply chains reach their maximum extent. This would suggest that within a mature market such as the UK, national distribution has become the norm for many products and sectors. Those that have not achieved this degree of geographical coverage by now may remain confined to particular regions as a result of resource endowments, consumer tastes and/or transport costs. The Continuing Survey of Road Goods Transport (CSRGT) provides some statistical evidence to support this view. It shows that the proportion of road freight tonnage moved inter-regionally increased from 22 to 32% between 1982 and 1997. Since then it has been fairly stable at 30–32% of total road tonne-km (Department for Transport, 2005c).

The extent of the area over which a company sources supplies and markets finished products is partly a function of the cost, speed and reliability of transport services. Rising levels of traffic congestion may therefore have been discouraging further lengthening of supply chain links, though testing of this hypothesis will require new empirical research.

The restructuring of domestic supply chains cannot be examined in isolation. As the UK is a major trading nation, with imports and exports of physical goods representing 17 and 21% of GDP, respectively (Office of National Statistics, 2005c), it is important to explore the effects of international trade on internal supply chains. This is discussed under the next heading.

11. Erosion of Industrial Activity to Other Countries

Over the past decade there has been a massive redistribution of industrial capacity from developed countries to the low labour-cost countries of the Far East and Eastern Europe (Dicken, 2003). This trend has accelerated in recent years as a result of China joining the World Trade Organization (WTO) and liberalizing its markets and the accession of Central and Eastern European states to the EU. Many UK-based companies have relocated manufacturing plants to these countries or been forced to scale down/close their operations in the face of intensifying global competition. This is reflected in the steep increase in the degree of import penetration in most industrial sectors over 1997–2003 (Table 6). Across 21 manufacturing SICs for which data are available, the import penetration ratio increased by an average of 50% over this 6-year period (Office of National Statistics, 2005c).

When a manufacturing plant is relocated to another country or its output is replaced by imports, the upstream and downstream supply networks can be dramatically altered. Many of the upper links in the supply chain also transfer to the foreign country as new overseas vendors are found. This is well illustrated by the case of the British household appliance manufacturer Dyson, which relocated the production of its vacuum cleaners from the UK to Malaysia in 2002. Materials and components that had previously been sourced from the UK and other EU countries were thereafter purchased from Far Eastern suppliers. Where manufactured goods are imported to the UK in their finished form, primary flows of raw materials and intermediate flows of components and sub-assemblies are removed from British roads. The movement of an imported product from the port is substituted for the outbound delivery of the UK-manufactured product which it displaces. Import journey legs may, on average, be slightly longer that the domestic distribution legs that they replace, but are very unlikely to offset the elimination of 'upstream' tonne-km. The net effect will be a significant reduction

Table 6. Change in import penetration ratio[a] by industrial sector, 1997–2002

Standard Industrial Classification (SIC)		Import penetration ratio 1997	2002	Percentage change
28	Fabricated metal products, excluding machinery	19	73	284
32	Radio, television and communication equipment	93	253	172
34	Motor vehicles, trailers and semi-trailers	56	134	139
22	Publishing, printing, recorded media	6	11	83
16	Tobacco	12	21	75
24	Chemicals, chemical products, man-made fibres	56	80	43
30	Office machinery and computers	105	146	39
35	Other transport equipment	62	79	27
17	Textiles and textile products	55	70	27
31	Electrical machinery and apparatus not elsewhere classified	55	69	25
18	Wearing apparel, dressing, dyeing, fur	77	93	21
19	Leather and leather products	83	96	16
36/37	Furniture and manufacturing not elsewhere classified	52	60	15
26	Other non-metallic mineral products	20	23	15
25	Rubber and plastic products	28	32	14
27	Basic metals	64	73	14
33	Medical precision, optical instrument, clocks	74	83	12
15	Food products, beverages and tobacco	21	23	10
20	Wood and wood products	35	38	9
29	Machinery and equipment not elsewhere classified	60	65	8
21	Pulp, paper and paper products	37	39	5

Source: Office of National Statistics (2005c).

[a]The import penetration ratio is defined as the "percentage ratio of imports to home demand" and "home demand … as total manufacturers' sales plus imports minus exports" (p. 306).

in the freight transport intensity of the British economy. This could be making an important contribution to the decoupling of road tonne-km and GDP trends, but one which it is not possible to quantify on the basis of currently available data.

12. Increase in the Real Cost of Road Freight Transport

Since 1995 the UK government has been compiling price indices for a series of 'corporate services' including road haulage (Office of National Statistics, 2005d). Between mid-1997 and mid-2004 the average price index for road haulage increased by 16.4% in real terms (Figure 10). No comparable data are available for the period before 1995, though research by Cooper *et al.* (1998) finds that between 1952 and 1995 lorry operating costs per km in the UK fell by an average of 1.37% per annum (in real terms). Between 1994 and 1999 vehicle-operating costs were partly inflated by the government's fuel duty escalator policy. This increased diesel fuel duty by 5% per annum in real terms between 1994 and 1997 and by 6% per annum in real terms between 1997 and the termination of the policy in 1999. Since 1999 the main cost pressures in road haulage have come from labour, insurance, traffic congestion, and, since 2003, the market price of fuel (Lex Transfleet Ltd, 2002; Freight Transport Association, 2004).

Vehicle-operating costs are also affected by the utilization of truck capacity. Over 1997–2004 the two main utilization measures, empty running and vehicle lading factor,[15] have moved in opposite directions (Department for Transport, 2005c). Between 1997 and 2004 the proportion of truck-km run empty fell from 28.2 to 26.8%, while the average weight-based utilization of trucks on laden trips also declined from 62 to 57%. This latter trend, however, is partly due to increases in maximum truck weight in 1999 and 2001 raising the carrying capacity of the heavy vehicle fleet. Average payload weight actually increased slightly from 6.5 tonnes in 1997 to 6.8 tonnes in 2004. The net effect of changes in average vehicle utilization on road freight rates over this period is likely, therefore, to have been quite small.

Increases in the real cost of road haulage would be expected to depress the demand for road freight movement. The price elasticity of demand for road transport, however, is relatively low. In forecasting the future growth of lorry traffic in 1997, the UK government assumed "the elasticity of HGV length of haul with respect to unit road freight costs … to be –0.1" (Department of the Environment, Transport and the Regions, 1998, p. 21).[16] This meant that for every 1% increase in the real cost of road transport, road tonne-km would decline by 0.1% (assuming that the number of tonnes-lifted would be unaffected by changes in road transport costs). Applying this elasticity value to the increase in average road haulage rates between mid-1997 and mid-2004 suggests that had this increase not occurred an extra 2.4 billion tonne-km of road freight movement would have been generated in 2004. This equates to roughly 12% of the 'gap' in road tonne-km that has resulted from the decoupling of GDP and road tonne-km trends.

The increase in the real price of road haulage is likely to have reinforced several of the trends discussed under previous headings, particularly numbers 4, 7, 8 and 10. By altering the financial trade-offs between transport and other commercial variables, it should have helped to slow the changes in the spatial structure of production and distribution that have been driving freight growth for several decades. It may also have contributed to the decline in road's share of the freight market. Some of these industrial responses should be captured by

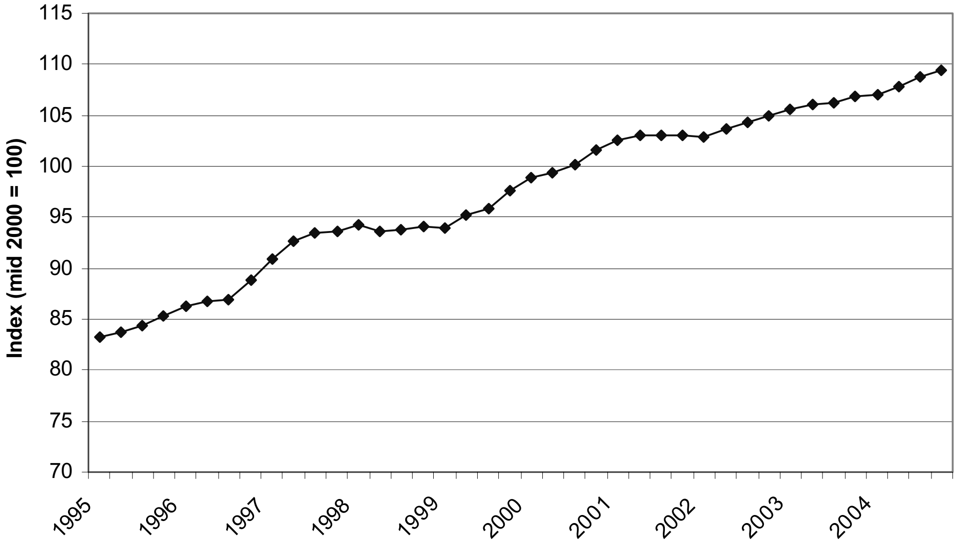

Figure 10. Corporate services price index for road haulage, 1995–2004. *Source*: Office of National Statistics (2005d)

the estimated price elasticity value for road freight. Increasing road haulage rates, however, are only one of several factors influencing these responses. These other factors, which have been discussed under the earlier headings, cannot be quantified at present.

Conclusion

This paper has examined possible causes of the decoupling of road tonne-km from GDP in the UK between 1997 and 2004. Table 7 assesses the relative importance of these causes. On the basis of the available data, it has been possible to quantify the contribution of only three of them, though collectively they could be responsible for around two-thirds of the divergence between the observed tonne-km and GDP trends.

Approximately one-third of the decoupling could be due to the increased penetration of the British road freight market by foreign hauliers. Road freight tonne-km have in fact been growing significantly faster than the CSRGT statistics suggest because they exclude the rapidly expanding activities of foreign operators in the UK. If tonne-km carried by foreign vehicles were included, the degree of decoupling would have been around 30% lower. The government recognizes this anomaly and, partly for this reason, prefers not to use road tonne-km as the main index in its analysis of decoupling trends. It focuses instead on the relationship between lorry-km and GDP and estimates lorry-km on the basis of roadside traffic surveys that monitor flows of foreign as well as UK-registered vehicles. Lorry-km also correlate much more closely than tonne-km with road freight externalities and freight's contribution to traffic congestion. Between 1997 and 2004, the ratio of total lorry-km (including those run by foreign trucks) to GDP declined by 11% (Department for Transport, 2006, p. 57). This is in keeping with the government's 10-year plan for transport that "aims to reduce lorry intensity,

Table 7. Estimated impact of the possible causes of decoupling

Possible cause of decoupling	Relative contribution (percentage or qualitative estimate)
1. Change in the systems of statistical accounting	very little
2. Dematerialization	little
3. Change in the composition of gross domestic product	significant
4. Decline in road's share of the freight market	22%
5. Increased penetration of UK haulage market by foreign operators	33%
6. Displacement of freight from trucks to vans	little
7. Reduction in the average number of links in the supply chain	little
8. Diminishing rate of spatial concentration	very significant
9. Improvement in the efficiency of vehicle routing	little
10. Domestic supply chains becoming fully extended	significant
11. Erosion of industrial activity to other countries	very significant
12. Increase in the real cost of road freight transport	12%

that is the extent to which economic growth generates additional lorry traffic" (Department for Transport, 2003b, p. 95).

Just under one-quarter of the decoupling can be attributed to a decline in road's share of the freight market. As rail and water-based services generate few externalities per tonne-km, this trend has yielded sustainability benefits. Furthermore, once allowance is made for the growth of tonne-km handled by these alternative modes, there was still significant decoupling of *total* tonne-km and GDP trends.

Five of the other causes (1, 2, 6, 7 and 9) are likely to have had little effect on decoupling. Of the remaining causes, a diminishing rate of geographical centralization and the erosion of production activity to other countries are likely to be significant and require further research. The latter process raises wider issues about the decoupling of freight transport and economic growth at different spatial scales and transfer of freight transport externalities to other countries. The off-shoring of manufacturing to Eastern Europe and the Far East reduces the freight transport intensity of Western economies, but at a global scale is increasing carbon dioxide and other emissions.

Another significant factor has been the accelerated growth of the service sector over the past 7 years. The fact that financial, business and public services now account for around half of Britain's GDP (Office of National Statistics, 2005c) and generate relatively small amounts of freight movement per £ billion of output casts doubt on the validity of GDP as the economic measure used in freight decoupling analyses. More research is required, however, on the freight-generating characteristics of different service activities.

This exploratory analysis indicates that the recent decoupling of road tonne-km and GDP trends in the UK does not in itself herald the arrival of a new era of sustainable logistics. Once allowance is made for the growth of foreign truck traffic on UK roads and the displacement of freight-related externalities to other countries, the net environmental benefits are likely to be much smaller than the statistical decoupling suggests. Unlike in most other EU countries, the decoupling is, from a public policy standpoint, in the right direction and appears to show that the spatial processes driving road freight growth are weakening. For

Britain to achieve its sustainable distribution goals (Department of the Environment, Transport and the Regions, 1999), however, the recent decline in the road tonne-km intensity of the UK economy will need to be supplemented by further reductions in empty running, higher vehicle load factors, improvements in fuel efficiency, tightening emission controls, and a continuing modal shift to rail and water.

Acknowledgement

The author would like to thank the two referees for their constructive and insightful comments on this paper.

Notes

1. As the present paper views decoupling from a road freight perspective, modal split is defined here as the division of freight tonne-km between road and alternative modes.
2. In trucks with a gross weight of 3.5 tonnes or more.
3. Transport intensity has several different definitions in the literature (e.g. SACTRA, 1999; Banister and Stead, 2002). In the present paper it is defined as the ratio of freight tonne-km to economic output.
4. This modal split stage in the framework is oversimplified as different modes have different handling factors and average lengths of haul. No mode-specific handling factors values are available for the UK over 1997–2004.
5. The modal shift cell is exceptional as it shows changes in a percentage value (i.e. road's share of the freight market) and not an absolute value. This explains why the average exponential growth values do not sum from left to right across the bottom of the diagram.
6. A new system of stratified sampling was introduced in 2004 to the Continuing Survey of Road Goods Transport for vehicles with gross weights of 33 tonnes and above. This is unlikely to have affected the tonne-km estimates. The decoupling of the road tonne-km and GDP trends was also well established before this change in sampling method took effect.
7. Note that shortening product life cycles may also, other things being equal, accelerate economic growth. This would tend to have a neutralizing effect on the tonne-km/GDP relationship.
8. No comparable data are available for the period since 1995.
9. Input–output tables indicate the level of external expenditure on different modes of transport and differentiate service from non-service sectors. The UK tables do not distinguish expenditure on freight and passenger services, however, nor is it possible to estimate the level of in-house expenditure on transport using this data source.
10. The CSRGT monitors the movement of freight within the UK by British-registered operators. The only international traffic it covers are the UK legs of cross-border journeys operated by British carriers.
11. Cabotage penetration rate is defined as the share of cabotage transport in total national transport, where total national transport is the sum of national and cabotage transport (by country in which cabotage takes place). (Sciullo and Smihily, 2005).
12. These handling factor estimates, like the value density figures discussed above, were imputed from international trade statistics. They are, therefore, subject to the same caveat issued by Kveiborg and Fosgerau (2004).
13. The Road Transport Directive is the application of the EU Working Time Directive to mobile workers in the road transport sector. It imposes restrictions on drivers' working time.
14. The average length of haul does not measure the mean trip length. Trips lengths relate to vehicle movements whereas the average length of haul applies to freight consignments. The two measures are, nevertheless, quite closely correlated.
15. Expressed as "the ratio of actual goods moved to the maximum tonne-km achievable if the vehicles, whenever loaded, were loaded to their maximum carrying capacity" (Department for Transport, 2005c, p. 28).
16. The Department of the Environment, Transport and the Regions (1998, p. 21) admitted it was "unable to model the elasticity of road freight traffic with respect to unit costs directly" and based its estimate on a review of previous research.

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