Global energy trends in road freight transport

Maja Piecyk
Alan McKinnon

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Research background

- This research was carried out as part of the project undertaken with the International Energy Agency (IEA).

- The transport sector is responsible for a large share of world energy use (26% in 2004) and constitutes a major source of GHG emissions (23% of world energy-related GHG emissions in 2004) (Kahn Ribeiro et al., 2007).

- More than three-quarters of the total transport energy use and related CO₂ emissions are attributable to the road transport sector (passenger and freight).

- The energy use by trucks is expected to increase by nearly 150% by 2050, as compared to 2000 level (WBCSD, 2004).
Globally, freight transport has been growing more rapidly than passenger transport and this is expected to continue in the future (Kahn Ribeiro et al., 2007).

### Projected growth of transport

#### Passenger transport

<table>
<thead>
<tr>
<th></th>
<th>Average Annual Growth Rates</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2000-2030</td>
<td>2000-2050</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.6%</td>
<td>1.7%</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>1.9%</td>
<td>2.1%</td>
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</tr>
<tr>
<td>Latin America</td>
<td>2.8%</td>
<td>2.9%</td>
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</tr>
<tr>
<td>Middle East</td>
<td>1.9%</td>
<td>1.8%</td>
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</tr>
<tr>
<td>India</td>
<td>2.1%</td>
<td>2.3%</td>
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</tr>
<tr>
<td>Other Asia</td>
<td>1.7%</td>
<td>1.9%</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>3.0%</td>
<td>3.0%</td>
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</tr>
<tr>
<td>Eastern Europe</td>
<td>1.6%</td>
<td>1.8%</td>
<td></td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>2.2%</td>
<td>2.0%</td>
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</tr>
<tr>
<td>OECD Pacific</td>
<td>0.7%</td>
<td>0.7%</td>
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<tr>
<td>OECD Europe</td>
<td>1.0%</td>
<td>0.8%</td>
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</tr>
<tr>
<td>OECD North America</td>
<td>1.2%</td>
<td>1.1%</td>
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</tbody>
</table>

#### Freight transport (road and rail)

<table>
<thead>
<tr>
<th></th>
<th>Average Annual Growth Rates</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>2000-2050</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.5%</td>
<td>2.3%</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>3.4%</td>
<td>3.1%</td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>3.1%</td>
<td>2.8%</td>
<td></td>
</tr>
<tr>
<td>Middle East</td>
<td>2.8%</td>
<td>2.4%</td>
<td></td>
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<tr>
<td>India</td>
<td>4.2%</td>
<td>3.8%</td>
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<tr>
<td>Other Asia</td>
<td>4.1%</td>
<td>3.7%</td>
<td></td>
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<tr>
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</tr>
<tr>
<td>OECD Europe</td>
<td>1.9%</td>
<td>1.5%</td>
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<td>OECD North America</td>
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<td>1.7%</td>
<td></td>
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</tbody>
</table>

Source: WBCSD (2004), Mobility 2030
Energy consumption and related CO₂ emissions

Gigatonnes CO₂-Equivalent GHGs/Year

Source: Mobility 2030, Reference case projections of transport-related WTW CO₂ emissions by mode, 2000–2050.
Energy demand in transport and freight transport growth

EU-25: Baseline scenario


Mtoe (megatoe) = one million toe
Toe – tonne of oil equivalent
1 toe ≈ 42GJ (10^9 J)
1 tonne diesel = 1.01 toe

Source: WBCSD (2004), Mobility 2030
Demand for road freight transport and related energy requirements

- The relationship between GDP and energy consumed by freight transport can be decomposed into a series of aggregate values and ratios.
- Similar approach has been adopted in previous EU research projects, e.g.
  - REDEFINE
  - SULOGTRA
  - Trilog – Europe
- Data requirements: only a few countries have sufficient data to calibrate the model.
Analysis of the key drivers

Key drivers of changes in road freight transport energy use:

- Economic growth (measured as GDP)
- Freight transport intensity (ratio of tonne-kms to GDP)
- Modal split (% of goods moved by different modes)
- Average payload weight
- Empty running
- Fuel efficiency (ratio of fuel consumption to vehicle-kms)
## Availability of data on key freight transport parameters around the world

<table>
<thead>
<tr>
<th>Data Country</th>
<th>Road Vehicle kms</th>
<th>Road Tonne-kms</th>
<th>Average payload weight on road</th>
<th>% empty running by trucks</th>
<th>Modal split</th>
<th>Energy consumption / fuel efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td></td>
<td></td>
<td>Tonne-km / laden km ratio for many countries</td>
<td>By tonne-kms and tonnes-lifted</td>
<td>Data available for some countries: UK, France, Germany, Spain, no time-series data Mainly for road / limited for rail</td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>US Canada</td>
<td>US Canada: only for for-hire carriers not own account</td>
<td>Possible to estimate US: tonne-km / vehicle km Canada: only for for-hire carriers</td>
<td>US: by tonne-kms and tonnes-lifted</td>
<td>US: road and rail Canada: only for rail</td>
<td></td>
</tr>
<tr>
<td>South America</td>
<td>Country data</td>
<td>may be available in local language</td>
<td></td>
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<tr>
<td>Asia</td>
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<td></td>
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<tr>
<td>Africa</td>
<td>RSA, Zambia</td>
<td></td>
<td></td>
<td></td>
<td>RSA, Zambia World Bank-railfreight data available</td>
<td></td>
</tr>
<tr>
<td>Australia &amp; New Zealand</td>
<td>Possible to estimate</td>
<td></td>
<td></td>
<td></td>
<td>Data available</td>
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</tr>
</tbody>
</table>

| Green Logistics | + comparability of data sets |
Relationship between GDP and the demand for surface freight transport

There has traditionally been a close relationship between GDP and tonne-kms. World Bank – a cross-sectional study of 33 countries using 1989 data → differences in GDP explained 89% of the variation in road tonne-kms.

Freight forecasting studies typically assume freight transport intensity to remain constant.

However, the analysis of freight transport intensity trends reveals wide differences in their recent trajectories but with most countries within the range +20% / -20%.
Decoupling of GDP and freight transport growth

Beyond a certain level of development freight transport intensity of an economy tends to decline. Main reasons:

- % GDP associated with production industries declines and much new economic growth comes from service activities which generate less freight tonne-kms per $1bn of output.

- As consumers’ income increases, the value density (i.e. ratio of value to weight) of the products they purchase tends to decline as they trade up to more expensive items.

- The geographical processes, mainly centralisation and wider sourcing, responsible for much of the past growth in tonne-kms, cannot continue indefinitely and eventually reach their maximum extent.

- Offshoring of manufacturing to lower cost countries.
In developed countries, GDP increases at a faster pace than the total mass of goods in the economy, mainly due to:

- greater share services % in GDP
- increase in value density of products

Confirms likelihood that there will be a longer term decoupling of GDP and tonne-kms trends.
Over the past 10 years UK GDP has been growing at a much faster rate than road
tonne-kilometres.

How many years of survey data does it take to confirm a long-term trend?

However, recent data suggest that these trends may be recoupling again.


Annual growth rates for GDP and road tonne-kms (Source: DfT, 2008)
Wide international variations in recent trends

(Sources: Eurostat, US National Transportation Statistics, Japan MILT, Canada UN Database, New Zealand National Freight Demand Study)
Modal split

Wide international variation in mode split

Net shift from rail to road

Source: Eurostat
Empty running

(measured as a percentage of total vehicle-kms)

% of truck-kms run empty

Trend in empty running of trucks in European countries
Average payload weight

(ratio of tonne-kms to laden vehicle-kms)

2007

International variation in average payload weight on laden trips

Trends in average payload weight on laden trips

Inconsistencies in the minimum gross weights of trucks (3.5 – 6 tonnes)
Fuel efficiency / energy intensity

Fuel Efficiency of Trucks in UK and US

litres / 1000km

Energy Intensity Trends in Various Countries

energy per tonne-kms

(Source: UK Dept for Transport, Davis et al 2008, Kamakate, 2007)
Conclusions

- Inter-relationships between key logistics variables and the total energy requirements of freight transport are very complex.

- There is a serious lack of statistics on surface freight transport systems around the world, particularly in the developing world.

- Where adequate data sets are available, the analysis revealed wide variations between reporting countries, even within the same continent.

- Different assumptions and data collection methods frustrate international comparisons of trends in some key parameters.
Conclusions

- Trends in some of the variables reduce the overall energy requirements of road freight transport (e.g. improvements in vehicle utilisation or fuel efficiency of trucks), while changes in others have the opposite effect (e.g. diversion of freight from rail to road, increasing freight transport intensity of national economies).

- Very difficult to quantify the overall demand for road freight-related energy solely on the basis of changes in individual variables.

- Disaggregated analysis enables better understanding of causes and drivers underlying this demand and provides a robust framework for the development of energy-conservation policies for road freight transport.
Contact details

Maja Piecyk
Research Associate
Heriot-Watt University
School of Management and Languages
Logistics Research Centre
Riccarton, Edinburgh
EH14 4AS

Tel. 0131 451 3305
Email: M.Piecyk@hw.ac.uk

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