Impact of External Factors on the Decarbonisation of Logistics Operations

Professor Alan McKinnon
Kuehne Logistics University

EcoTransIT World Workshop

Gothenburg

18 November 2015
A private, independent, state-accredited university – founded in 2010

A university with expertise in logistics and management

2 MSc, a Bachelors, an executive MBA and a PhD programs – 250 students

19 resident faculty plus contributions from a group of external professors

3rd business school in Germany in terms of research performance (Handelsblatt 2014)
Climate Challenge for the Freight Transport Sector

5th Assessment Report of the IPCC

Transport:

2010: 7 billion tonnes of CO$_2$e
2050: 12 billion tonnes of CO$_2$e

2050 limit on CO$_2$e emissions from all activity: **20 billion tonnes**

To retain its 14% share transport must reduce CO$_2$e emissions to

2.8 billion tonnes by 2050

freight transport = one of the hardest sectors to decarbonise

On a BAU basis, freight share of total GHG emissions likely to rise from

7% (2010) to 16% (2050)
Forecast Growth in Surface Freight Tonne-kms and CO₂ to 2050 (2010=100)

Company targets to reduce the carbon intensity of logistics

<table>
<thead>
<tr>
<th>company</th>
<th>normaliser</th>
<th>time period</th>
<th>% carbon reduction target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deutsche Post / DHL</td>
<td>‘every letter and parcel delivered, every tonne of cargo transported and every sq.m. of warehouse space’</td>
<td>2007-2020</td>
<td>30%</td>
</tr>
<tr>
<td>DB-Schenker</td>
<td>Tonne-km</td>
<td>2006-2020</td>
<td>At least 20%</td>
</tr>
<tr>
<td>UPS</td>
<td>UPS Transportation Index</td>
<td>2010-2017</td>
<td>5%</td>
</tr>
<tr>
<td>UPS Airlines – Global</td>
<td>Pounds of CO₂ emitted for every ton of capacity transported on nautical mile</td>
<td>2005-2020</td>
<td>20%</td>
</tr>
<tr>
<td>FedEx (aircraft)</td>
<td>available ton mile (ATM)</td>
<td>2005-2020</td>
<td>20%</td>
</tr>
<tr>
<td>TNT (Mail and Express)</td>
<td>not specified</td>
<td>2007-2020</td>
<td>45%</td>
</tr>
<tr>
<td>Maersk Line</td>
<td>not specified</td>
<td>2007-2020</td>
<td>25%</td>
</tr>
<tr>
<td>NYK</td>
<td>‘unit of transportation from vessels’</td>
<td>2006-2013</td>
<td>10%</td>
</tr>
</tbody>
</table>

Source: McKinnon and Piecyk, 2012

40% improvement in carbon intensity of global logistics between 2010 and 2020

Internal company initiatives - supported or offset by external trends
Assessing the effect of external factors on the decarbonisation of logistics

**TIMBER framework**

categories of external factor

- Technology
- Infrastructure
- Market
- Behaviour
- Energy
- Regulation
Assessing the effect of **external** factors on the decarbonisation of logistics

TIMBER framework

categories of external factor

- Technology
- Infrastructure
- Market
- Behaviour
- Energy
- Regulation

- Modal split
- Utilisation
- Fuel efficiency
- Energy mix
Assessment of the Influence of **External** Factors on Logistics Decarbonisation

<table>
<thead>
<tr>
<th>Region</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>Germany / Austria / Switzerland, UK, Netherlands, France, Italy</td>
</tr>
<tr>
<td>North America</td>
<td>US, Mexico</td>
</tr>
<tr>
<td>Asia</td>
<td>China, India, Indonesia</td>
</tr>
<tr>
<td>Africa</td>
<td>South Africa</td>
</tr>
</tbody>
</table>

- **Professor Cees Ruijgrok** (Netherlands)
- **Dr Jacques Leonardi** (France)
- **Clean Air Asia** (China)
- **University of Stellenbosch** (South Africa)
- **Mr. Sudhir Gota** (India and Indonesia)
Potential for Decarbonising Freight Transport in 15 Countries: 2010 - 2050

- Decoupling of freight tonne-km from GDP
- Decoupling energy use from freight t-km
- Decoupling freight energy use from related emissions

freight transport intensity
energy intensity of freight transport
carbon intensity of freight energy

Source: IDDRI / SDSN (2014) 'Pathways to Deep Decarbonisation'
Methodology

Literature review:
• government reports and statistics
• reports of international organizations, consultancies, research institutes
• academic papers

Interviews with country experts

Interviews with Unilever managers in each of the countries

Expert workshop, KLU 5 May 2015
Low Carbon Technologies for Trucks

**UK**
- Conventional Vehicle
- Improve Efficiency of Powertrain
- Reduced Power required by vehicle
- Reduce Power required by vehicle
- Improved Vehicle Energy Efficiency
- Reduce Carbon in Fuel

**Low Carbon Vehicle**
- Potential benefit
  - Reduced rolling resistance: 5% (high speed)
  - Reduced aerodynamic drag: <11% (high speed)
  - Energy recovery (hybrid): 20% (city)
  - Waste heat recovery: 5%
  - Higher combustion efficiency: 2-3%
  - Ancillaries: 5%
  - Automated manual trans.: 10% (city)

**Source:** Ricardo (2010)

**France**
- 100% Energie du gazelle
- 19% Penetration dans l’air
- 19% Résistance au roulement
- 4% Fricions internes moteur
- 3% Friction chaîne cinématique

**US**
- 23% Reduction in CO2
- MY 2010 baseline: 94 g/ton-mile
- MY 2017 target: 72 g/ton-mile

**US Supertruck project**
- Improving the fuel efficiency of American trucks — bolstering energy security, cutting carbon pollution, saving money and supporting manufacturing innovation
- February 2010

**Technology**
- Base (MY2010)
- Engine
- Aero (Bin III)
- Drive tires
- Steer tires
- Idle reduction
- Weight reduction
- Speed limiter (60 mph)
International Variations in Truck Technology

1. **Baseline fuel efficiency**: wide variations across sample of countries

2. **Rates of vehicle replacement and equipment retrofitting**:

   ![Bar chart](chart1.png)  
   - **Germany**, **US**, **EU (average)**, **Chile**, **South Africa**, **Indonesia**, **Brazil**, **Latin America (average)**, **Mexico**
   - **Average age of national truck fleet**

3. **Fuel prices**:
   - US $1 per litre - UK ($2.16), the Netherlands ($1.93) and Germany ($1.77)
   - **Withdrawal of diesel fuel subsidies (Indonesia and India) – during period of low oil prices.**

   ![Graph](graph1.png)  
   - **Trucking innovation uptake rates in US**
   - **Source**: NACFE (2014)

   ![Graph](graph2.png)  
   - **% of truck fleet with radial tyres**
4. *Infrastructural constraints*

![Graph showing vehicle resistive forces and speed]

- **On use of aerodynamic profiling**
  - Aerodynamic forces
  - Tire rolling resistance
  - Internal vehicle friction (gear box, drive shaft, bearings, ...)

- **Indian average speed**
- **EU average speed**

5. *Vehicle construction and use regulations*

**High capacity vehicles**

<table>
<thead>
<tr>
<th>National permission</th>
<th>State-level permission</th>
<th>Trial</th>
<th>Not allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>United States</td>
<td>Germany</td>
<td>Austria</td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td>UK</td>
<td>China</td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
<td></td>
<td>France</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>India</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Indonesia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Switzerland</td>
</tr>
</tbody>
</table>

- Unpaved / under-maintained roads
  - Inhibits tyre and drive-train upgrades

6. *Fuel economy and emission standards*

![Map showing national emissions standards for diesel trucks (2014)]

Source: [www.transportpolicy.net](http://www.transportpolicy.net) (ICCT / Dieselnet)
Infrastructure

1. Easing present / future traffic congestion

Peak-period congestion on the national highway system

German federal infrastructure plan (2003): estimated likely reduction in freight carbon intensity from infrastructural expansions / upgrades

2. Promoting modal shift to rail

expanding loading gauge (UK)

improving road access to intermodal terminals (US)

corridor-based rail freight strategies (India, Mexico, EU)
Market

1. Freight modal split:

Typically rail has 65-80% lower carbon intensity than road
Rail increasing market share in some countries

![UK](image1.png)

![Mexico](image2.png)

2. Restructuring of the freight market: *road haulage sector remains highly fragmented*

3. Online freight procurement: *mature market in Europe and North America
limited application as yet in emerging markets*

4. Collaborative initiatives:

Momentum building for horizontal collaboration across supply chains,
especially in EU FMCG sector
Depends on the anti-trust laws and maturity of the logistics market

5. Industry-wide green freight initiatives: *Lean and Green, GFA, GFE, LCRS etc.*
Behaviour

Behaviour of staff operating vehicles / logistics equipment

With driver training and fuel performance monitoring: *typical 5-10% fuel efficiency gain*

**Carbon Reduction Measures Adopted by Members of UK Logistics Carbon Reduction Scheme (LCRS)**

- More frequent tyre inflation checks
- Greater use of double deck vehicles (or high cube vehicles)
- Periodic maintenance and inspection that includes items that affect fuel efficiency
- Reduce empty running
- **Eco-driver training**
  - Install cab roof air deflectors
  - Improve vehicle fill on laden trips (by weight and/or volume)
  - Reduce engine idling
  - Adopt vehicles with automated manual transmission
- **Monitoring driver fuel performance**

- Automatic tyre inflation systems
- Low friction drive train lubricants
- Low friction engine lubricants
- Tare weight reduction
- Wide-base tyres
- Improved Trailer Aerodynamics
- Improved Tractor Aerodynamics
- **Driver training and monitoring**
- Idling reduction (automatic engine idle)
- Maximum speed reduction (65-60 mph)

Source: Ang-Olsen and Schroeer

**External factor in the sense that:**

- a country’s population of truck drivers is conditioned to attach a certain amount of importance to fuel efficiency
- some governments provide support for truck eco-driving schemes
- affected by levels of truck telematics and on-board fuel monitoring equipment in the national truck fleet

**China’s 12th 5 year plan:**

- 70% increase in number of truck drivers given training in eco-driving between 2007 and 2020 – 2.1% fuel saving
Energy

Power shift in the logistics sector to low carbon electricity

Carbon intensity of electricity generation in the countries studied (gCO2 / kWh)

**Germany:** increase renewable share from 25% in 2013 to 35% in 2020

Average carbon intensity of electricity generation

- **UK**
  - 2010: 496g / kwh
  - 2020 target: 222g / kwh

Getting low carbon electricity into the freight sector

Short-term: *electrified rail and local delivery operations*  
Long-term: *electrified roads*

- recharging infrastructure
- future battery performance
- E-vehicle price differential
biofuel fuels: very limited uptake

- uncertainty about net GHG impact
- limited supply of biogas
- inter-sectoral competition for biogas
- lack of refueling infrastructure
- methane slip problem with dual fuel trucks
- different national renewable fuel targets

Main switch to biofuels through biodiesel blends of 5-7% e.g. UK

EU Renewable Fuels Obligation: 10% renewable energy in transport by 2020

China: 2013 Biofuels Annual Report - biofuels to be 10% of all liquid fuels by 2020, but trend flattened recently....
Overloading is very common in developing countries
Low level of regulatory enforcement and fines
Problem compounded by poor vehicle maintenance
Damage to road surface – reduces fuel efficiency
Overloading carries a high fuel and CO₂ penalty
Assessing the Future / Past Impact of Sustainable Logistics Policies

China 12th 5 year plan:
estimated energy savings in road freight sector


<table>
<thead>
<tr>
<th>Main objective</th>
<th>Level of success (1-5)</th>
<th>Examples of Type of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation</td>
<td>4</td>
<td>Speeding up public decision making</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taking the lead internationally, and in PPP’s</td>
</tr>
<tr>
<td>Collaboration</td>
<td>3</td>
<td>Taking the lead in triple helix</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Act as broker to combine interests</td>
</tr>
<tr>
<td>Logistics networks</td>
<td>2</td>
<td>Stimulate synergy in creating networks including main ports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taking the lead in projects of national importance</td>
</tr>
<tr>
<td>Intermodal networks</td>
<td>4</td>
<td>Investments in intermodal infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Investment in supporting ICT</td>
</tr>
<tr>
<td>SCM</td>
<td>3</td>
<td>Introducing of common standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stimulating Control Towers</td>
</tr>
<tr>
<td>Sustainability</td>
<td>3</td>
<td>Subsidizing sustainable technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased awareness</td>
</tr>
<tr>
<td>Innovation</td>
<td>2</td>
<td>Enhancing customer</td>
</tr>
</tbody>
</table>

Other policies have an impact on the carbon intensity of logistics
Relative importance of the TIMBER factors
**Comparative Logistics Data: UK and Germany 2010-11**

<table>
<thead>
<tr>
<th>parameter</th>
<th>UK</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight carbon intensity (g CO₂/tonne-km)</td>
<td>185</td>
<td>162</td>
</tr>
<tr>
<td>Average length of haul (road+rail) – index</td>
<td>100</td>
<td>149</td>
</tr>
<tr>
<td>% of truck-kms run empty – index</td>
<td>100</td>
<td>86</td>
</tr>
<tr>
<td>Truck average payload weight – index</td>
<td>100</td>
<td>130</td>
</tr>
<tr>
<td>% of trucks less than 2 years old – index</td>
<td>100</td>
<td>153</td>
</tr>
<tr>
<td>Annual truck replacement rate – index</td>
<td>100</td>
<td>147</td>
</tr>
</tbody>
</table>

**freight modal split 2010**

- **Road**
  - UK: 90
  - Germany: 60

- **Rail**
  - UK: 10
  - Germany: 20

- **Waterborne**
  - UK: 10
  - Germany: 20
### TIMBER Scenario 1: OPTIMISTIC

#### Technology
- Rate of technology advance and uptake in the logistics sector at upper end of projections
- More rapid diffusion of low carbon technologies (LCTs) to developing countries / emerging markets
- IT advances (e.g. analytics, big data and cloud computing) translate into much greater CO₂ efficiency

#### Energy
- Rate of decarbonisation of grid electricity at upper end of projections
- 2nd and 3rd generation biofuels shown to yield significant net GHG savings at affordable cost
- Extensive use of micro-generation at logistics facilities where climatic conditions are favourable

#### Infrastructure
- Congestion minimised by capacity increases, improved infrastructure management and road pricing
- Prioritised investment in rail, inland waterways and ports promotes significant shift to these alternative modes
- Extensive gas refuelling and battery-recharging networks in place

#### Behaviour
- Eco-driving is standardised by compulsory training
- Electronic monitoring of driver behaviour becomes universal
- In-cab guidance systems, smart cruise control and ultimately automation over-ride deficiencies in driver behaviour

#### Market
- Large increase in horizontal and vertical collaboration in FMCG supply chains
- Full harmonization of carbon auditing and reporting by logistics providers and carriers
- Load fill and minimization of transport CO₂ prioritised over inventory reductions
- Competitiveness of rail-freight services enhanced by liberalization / privatization and corridor planning

#### Regulation
- Truck size and weight limits are relaxed with measures to minimise adverse effect on rail’s market share
- More governments introduce vehicle scrappage schemes to accelerate adoption of LCT across the truck fleet
- Proliferation and harmonization of national fuel economy standards for trucks
TIMBER Scenario 2: PESSIMISTIC

Technology
- Rate of technology advance and uptake in the logistics sector at the lower end of projections
- Diffusion of low carbon technologies (LCTs) to emerging markets restricted by cost factors, import controls etc
- Business practices and corporate governance prevent IT innovations from being fully exploited

Energy
- Rate of decarbonisation of grid electricity at the lower end of projections
- Transport usage of biofuels remains low due to concerns about net GHG impacts, land use effects etc
- Low ‘feed-in’ tariffs and poor rates of return discourage micro-generation at logistics facilities

Infrastructure
- Traffic growth exceeds additional infrastructural capacity increasing congestion and related CO₂ emissions
- Limited improvement to rail and water-borne infrastructures as investment in passenger rail, highways and aviation are prioritised
- Gas refuelling and battery-recharging networks are slow and expensive to develop

Behaviour
- Eco-driving remains patchy, particularly in the developing world
- Adoption electronic monitoring of driver behaviour proceeds at a slow rate
- Use of technology to control vehicle operation is resisted by trade unions and owner drivers in many countries.

Market
- Collaborative initiatives in the FMCG sector stabilise at a low level because of corporate inertia, managerial scepticism, legal constraints etc
- Comparing the carbon / environmental performance of carriers remains inconsistent and difficult
- JIT pressures intensify in the FMCG sector forcing reductions in load fill and transport-CO₂ increases
- Modal shift to rail continues to be inhibited by a lack of competitiveness in the rail / intermodal sectors

Regulation
- Strong resistance from the railways and environmental organisations discourages governments and EU from relaxing truck size and weight limits
- Governments are reluctant to commit the large sums requires to rejuvenate national truck fleets
- National fuel economy standards for trucks remain confined to the US, China and Japan
Gaining Decarbonisation Leverage from TIMBER factors: *Recommendations to Companies*

TECHNOLOGY (T1-8)

1. Review available data (in main report) on potential carbon savings from truck technologies, future trajectories, uptake rates and cost effectiveness.
2. Assess client expectations of future level of carbon emissions from their logistics operations and willingness to pay for low carbon technologies (LCTs).
3. Regularly recalibrate carbon modelling tools to reflect impact of LCTs, especially in countries with tightening fuel economy standards.
4. Take advantage of any government schemes for vehicle scrappage and/or incentivising the purchase of lower CO₂ vehicles.
5. Partner with vehicle and equipment manufacturers to pilot new LCTs in logistics.
6. Exchange information with shippers/clients on new logistics-related LCTs, either directly or through green freight organisations.
7. Establish joint initiatives with larger shippers/clients to develop/trial of new LCTs.
8. Assess options for switching to alternative fuels: systematic reviews of the cost, quality, availability and carbon intensity of alternative fuels.

INFRASTRUCTURE (I 1-6)

1. Review available data (in main report) on infrastructural trends and developments and their likely impact on carbon intensity.
2. Take full account of planned road improvements in the planning of DC locations and delimitation of their service areas.
3. Assess the effect of planned changes in rail/water-borne/intermodal infrastructures on the relative attractiveness of a shift to lower CO₂ modes.
4. Ensure that vehicle routeing systems are sensitive to changes in the quality/reliability of road and rail networks.
5. Take account of fuel consumption and CO₂ emissions when planning vehicle routes and schedules.
6. Work with shippers/clients to find ways of rescheduling deliveries into off-peak periods to minimise impact of congestion on CO₂ emissions.
Key messages

Benefit in tracking macro-level trends and policy initiatives to find opportunities for external leverage - can give country-specific examples

Nature and strength of the trends vary significantly by country

Considerable interaction between the ‘external trends’ and internal decisions e.g. in modal choice, transport procurement, participation in green freight schemes, collaborative initiatives - blurs distinction between external – internal

Important inter-relationship between TIMBER factors – usually mutually reinforcing

Opportunities for building results of a TIMBER analysis formally into company-level logistics decarbonisation modelling are limited

National and international green freight initiatives are helping to cross-fertilise good practice in carbon reduction – though still at an early stage in their development

Study highlights deficiencies in data collection (even in developed countries) – making the formulation and assessment of macro-level carbon reduction policies difficult
Professor Alan McKinnon

Kühne Logistics University – the KLU
Wissenschaftliche Hochschule für Logistik und Unternehmensführung
Grosser Grasbrook 17
20457 Hamburg

tel.: +49 40 328707–271

e–mail: Alan.McKinnon@the-klu.org
website: www.the-klu.org