ECEEE Summer Study

We Keep on Truckin': Trends in Freight Energy Use and Carbon Emissions in 10 IEA Countries

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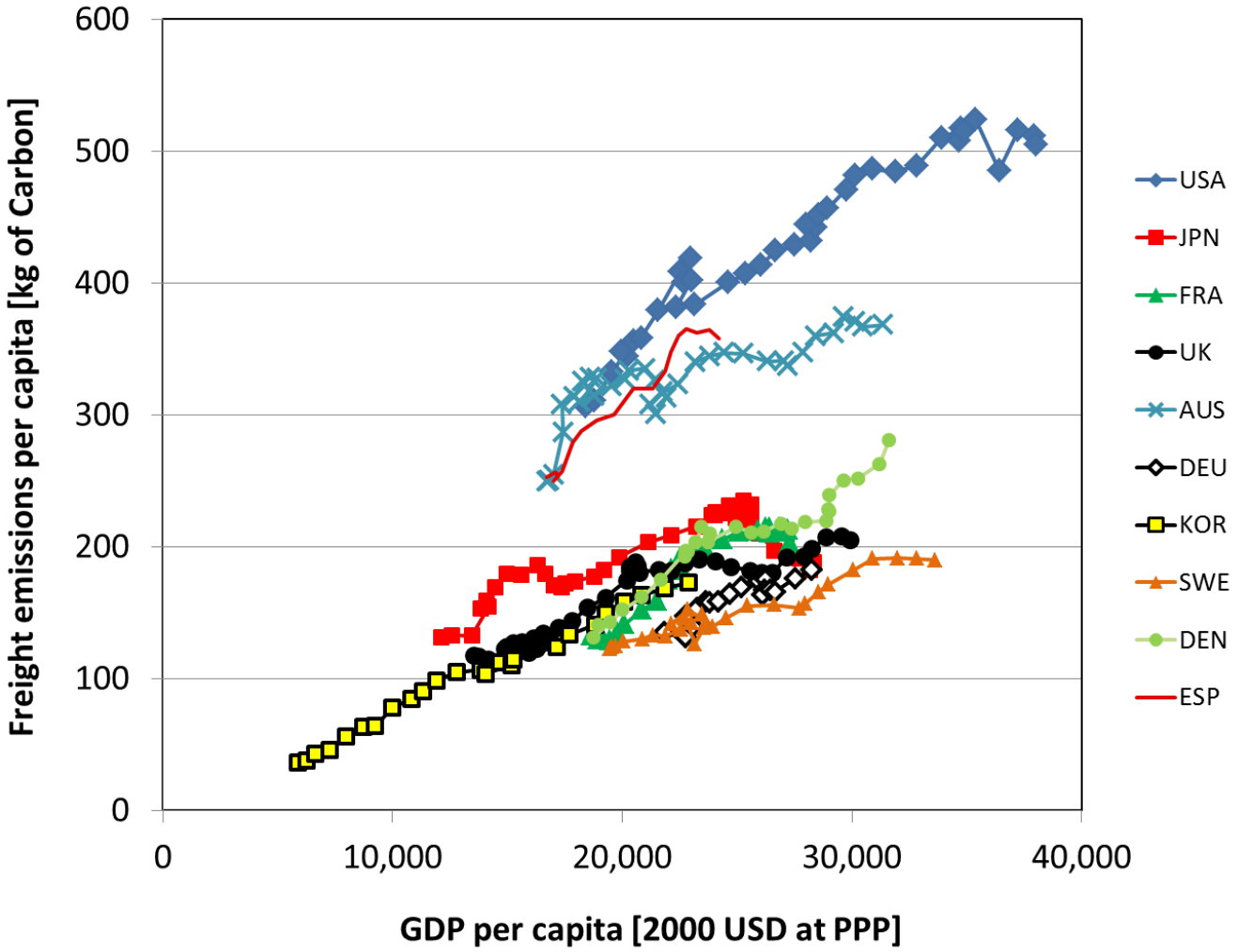
Per capita freight carbon emissions: Why are they so different?



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Motivation

- The analysis of freight transportation energy utilization is not easy:
  - Driven mainly by business-related activities
  - Dependent on spatial allocation of economic activities
  - Interaction with passenger transportation (e.g., road and railway)
- Not much attention has been paid by the literature
  - Freight is important: Schipper et al. (1997), Schipper and Marie-Lilliu (1999) and Kamakate & Schipper (2009)
  - Detailed analysis of UK trucking (McKinnon and colleagues last 10 years)
  - The role of GDP structure: Sorrell et al. (2010)
- But, over the last two decades, freight as a source of CO_2 has grown faster than travel in many developed countries.
- And, their trends vary widely across the countries.

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Objectives

- Compare the energy and CO_2 intensity of freight transportation across 10 major IEA countries
  - Two 'large' countries: USA and Australia
  - Six European countries: France, UK, Germany, Sweden, Denmark, and Spain
  - Two Asian countries: Japan, and South Korea
- Understand major forces driving freight CO_2 emissions
- Interpret the results and implications for
  - Each mode's role in CO_2 emissions
  - Freight transport planning and policy

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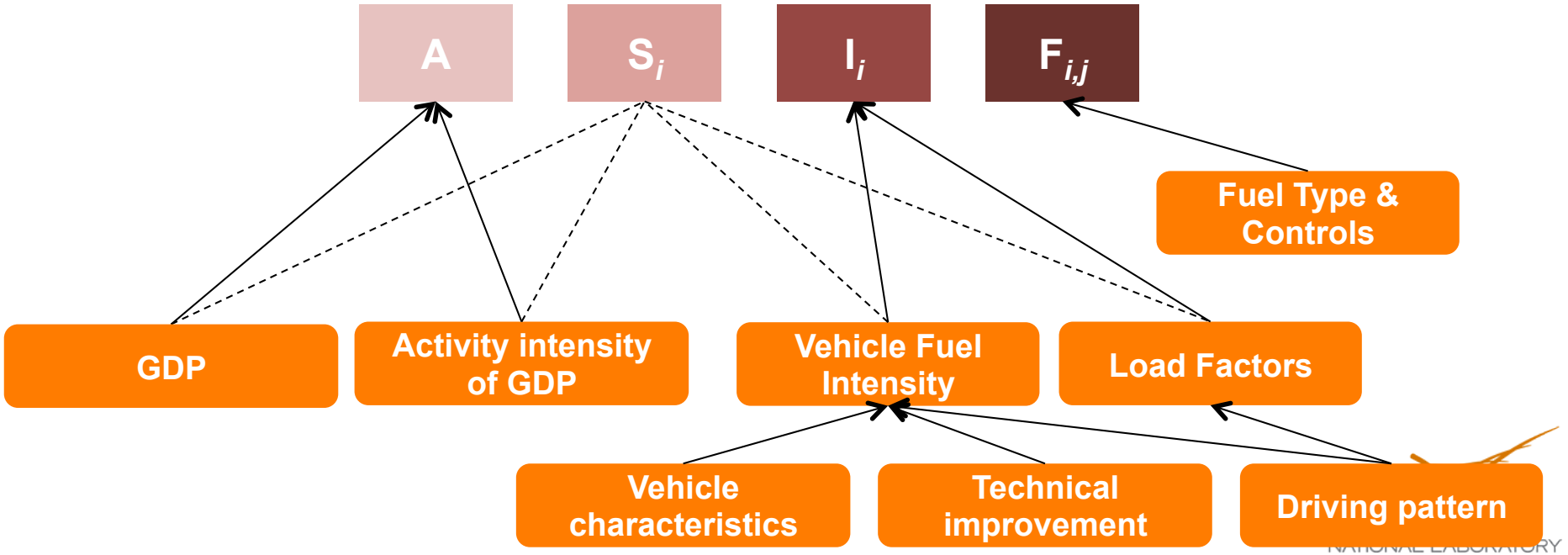
Decomposition of Freight CO_2 Emissions

- CO_2 Emissions =
  - **A**ctivity: freight service demand [tonne-km]
  - × **S**hare of freight modes: tonne-km share by mode [%]
  - × **I**ntensity of modal energy: energy use rate for each mode [MJ/tonne-km]
  - × **F**uel mix: CO_2 content of energy for each mode [gC/MJ]

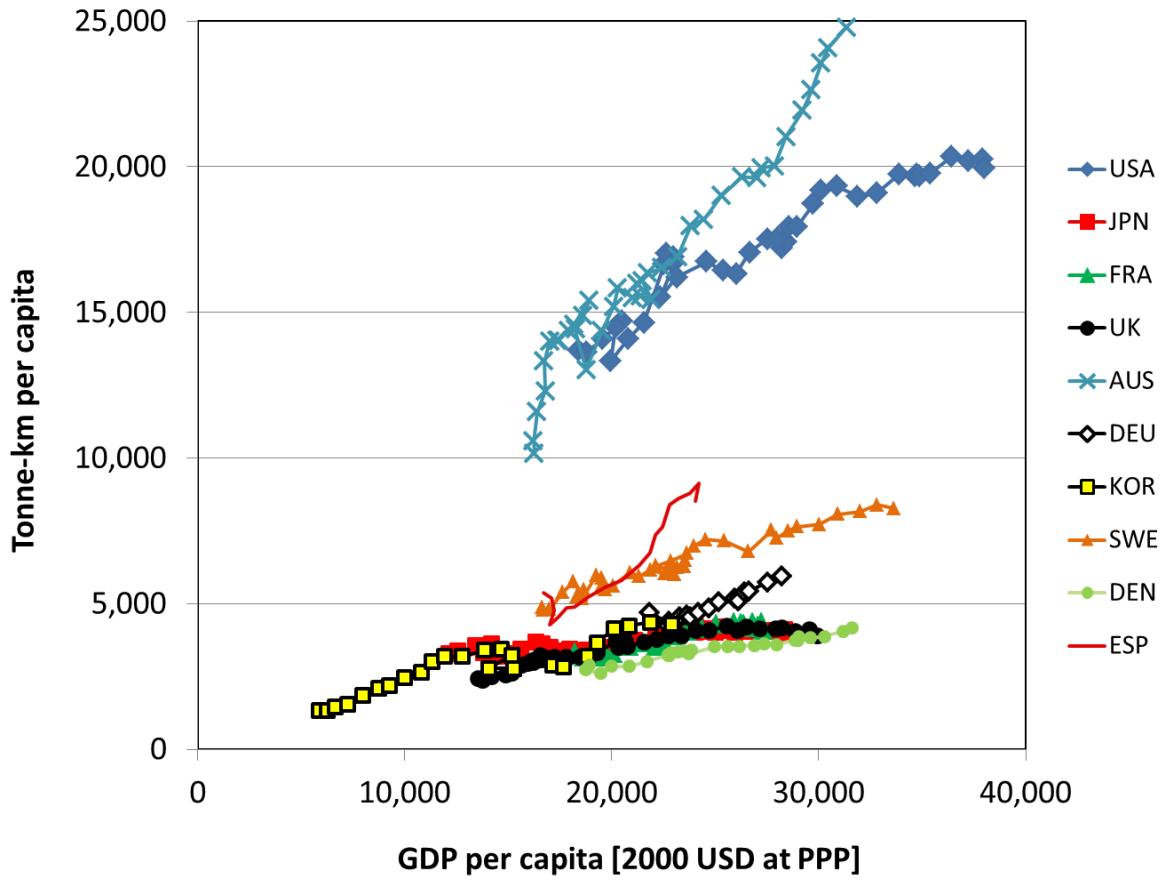


Data Sources

- Coverage
  - Includes domestic land-based freight related to import/export
  - Includes fossil fuel freight
  - Excludes international transit freight
  - Excludes natural gas and oil in pipelines
- Data Sources
  - Australia: Australia Bureau of Statistics, ABARE, Apelbaum Associates
  - France: Ministère de l'Ecologie, du Dévelopment et de l'Aménagement Durables
  - Japan: Ministry of land, infrastructure, and transport, Energy Data and Modeling Center
  - Korea: Korea energy economics institute, Ministry of Land, Transport, and Marine Affairs
  - United Kingdom: Department for Transport, Department of Trade and Industry
  - United States: Transportation energy data-book (ORNL), Bureau of Transportation Statistics
  - Germany: Deutsches Institut für Wirtschaftsforschung (Verkehr in Zahlen)
  - Sweden: Statens Institute for Kommunikations Analyser, Sveriges Officiella Statistik
  - Denmark: Vej direktorat, Energistyrelsen
  - Spain: IDEA, Anuario Estadístico de Fomento
  - Statistique Internationale des Chemins de fer, Odyssee Database
  - Dataset established by Schipper, Scholl, and Price (1997) and Kamakate and Schipper (2009)

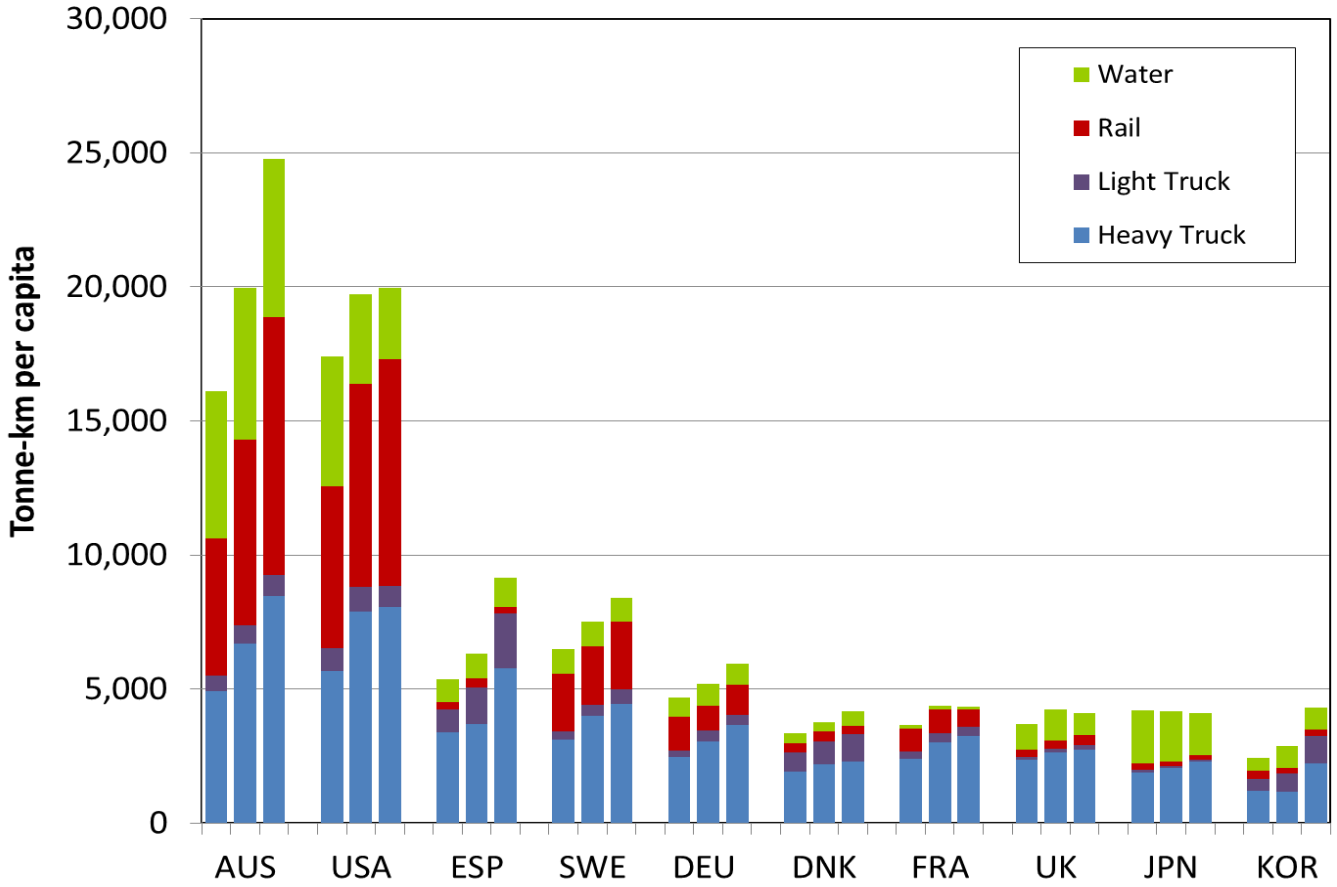
Freight Activity vs. GDP

- Very different relationships as judged by freight-GDP slope
  - International shipping excluded, but domestic portion of freight to ports or borders hauled by domestic truck/rail included
- Importance of geographical coverage, fossil fuel freight, and cross-border trading.



Modal Shares in 1990, 2000, and 2007

- The two largest countries have used trucking intensively, but their trucking shares are still the lowest because of high use of rail and shipping for raw materials.
- Trucking shares have increased in all countries, mostly result of demands for faster shipping of final products.



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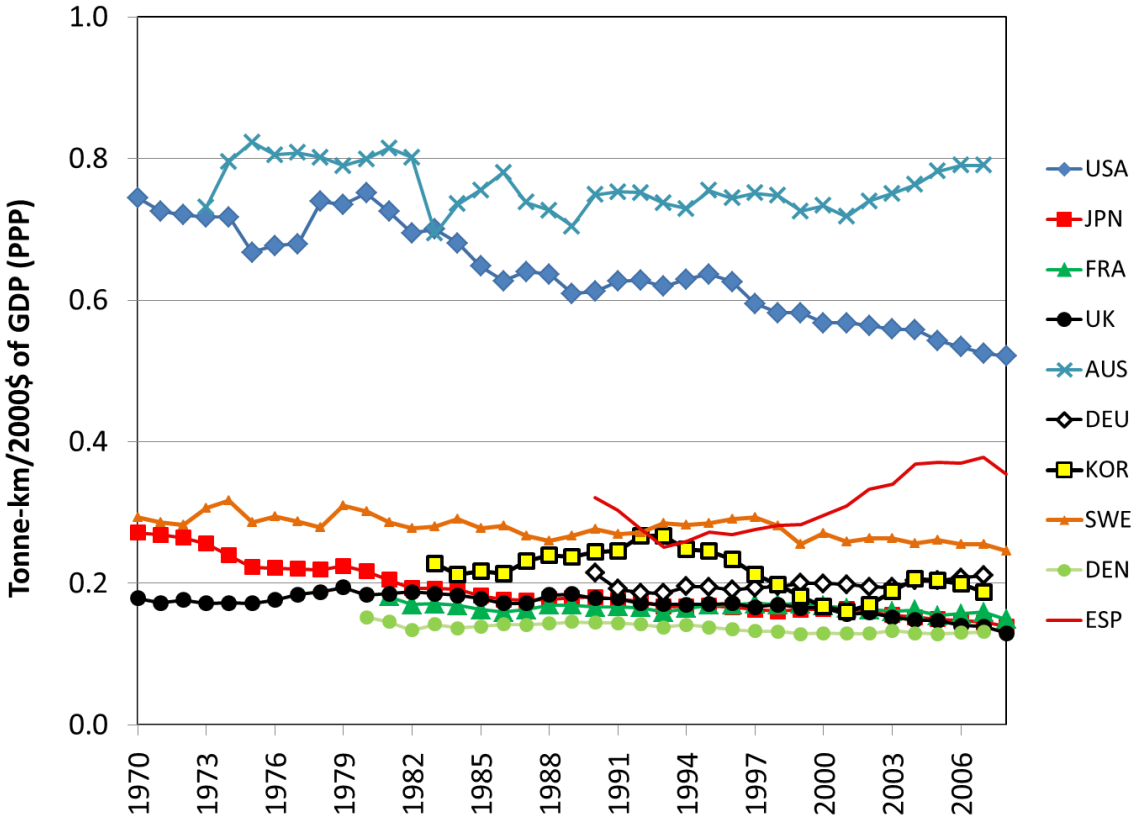
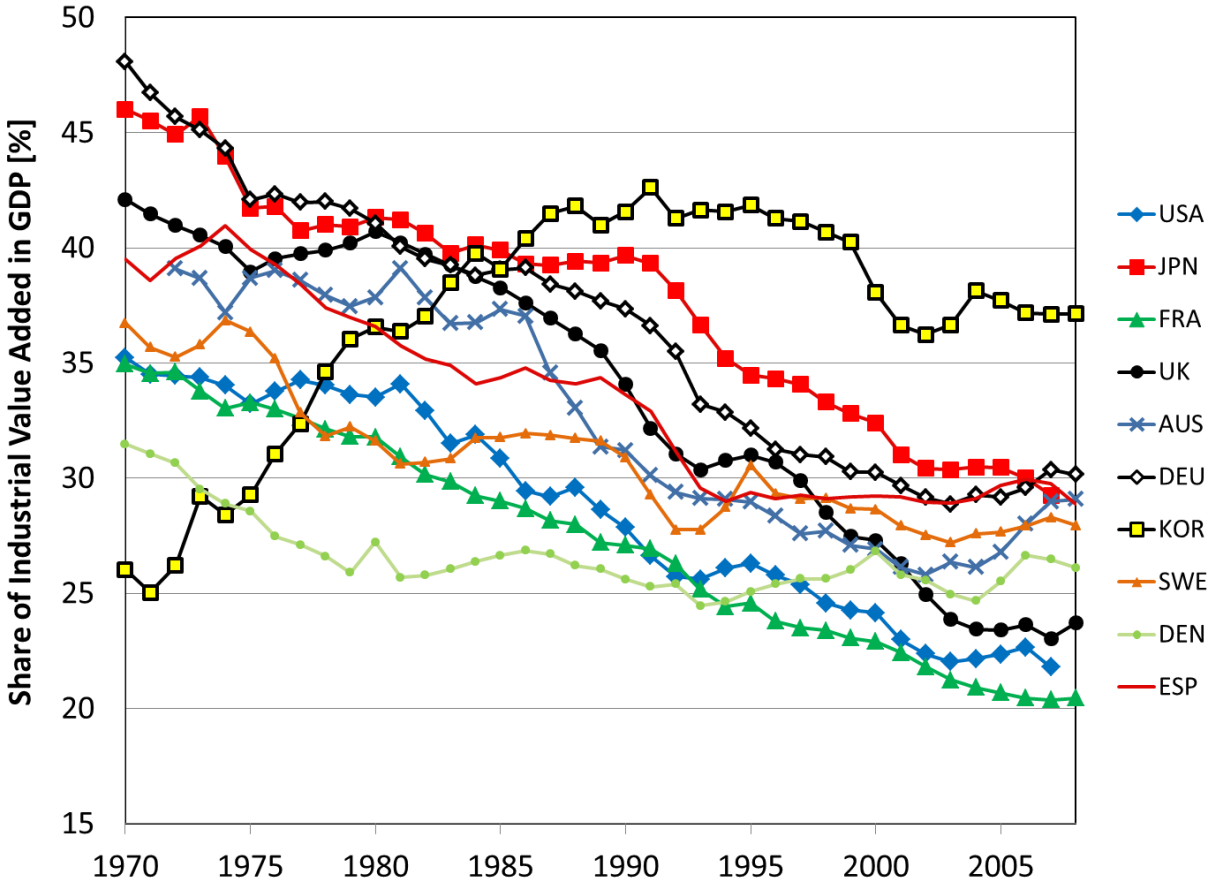
Domestic Freight Activity and GDP:
Can they be decoupled?

- Many countries have experienced sizeable changes.
- Country-level fluctuation is smaller than the variation across the countries.
- The degree of the coupling generally decreased, but in some cases increased.



The Share of Industrial Value Added to GDP

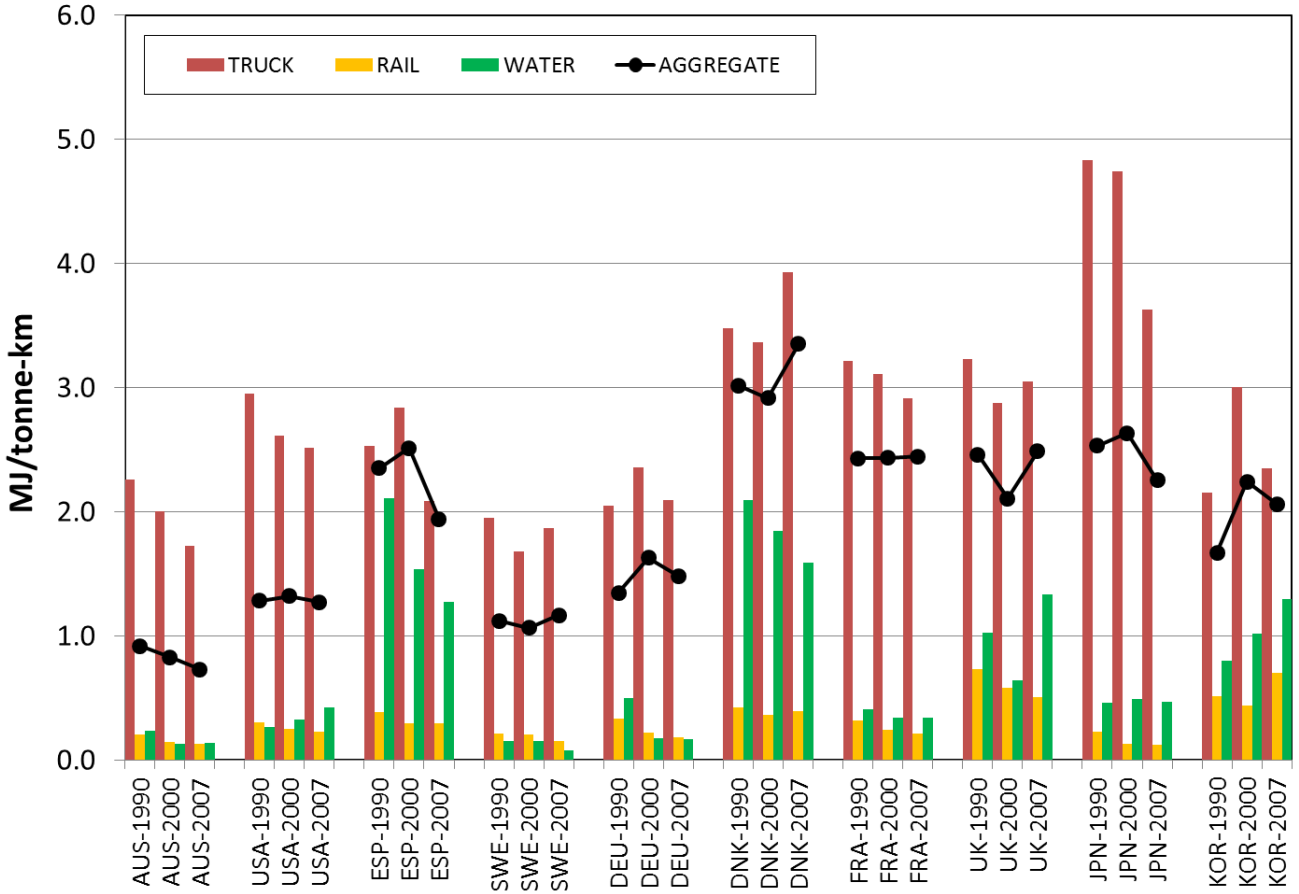
- The trends in the freight activity intensity of GDP have largely been coupled with changes in the share of industrial value added to GDP.



Source: World Development Indicators (World Bank)

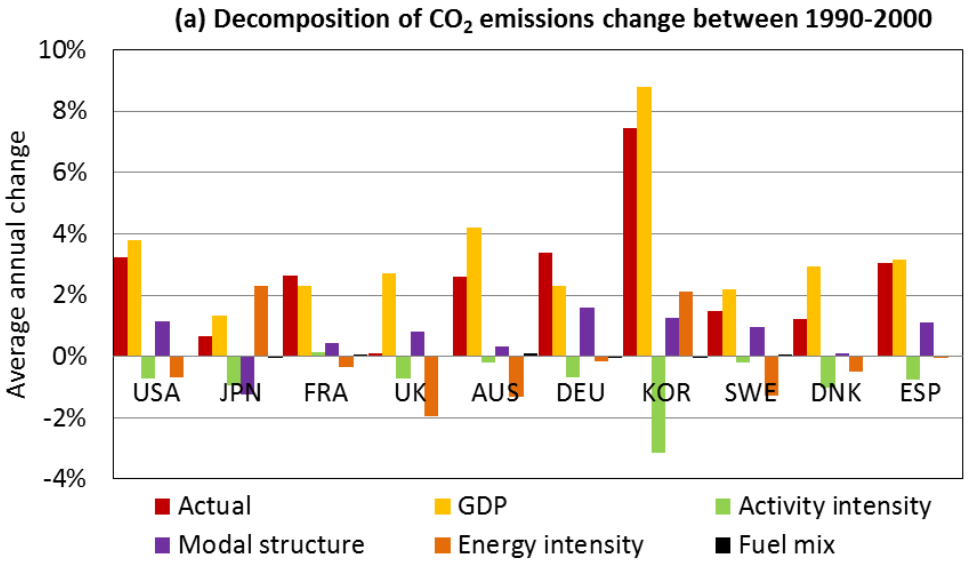
Modal Energy Intensities

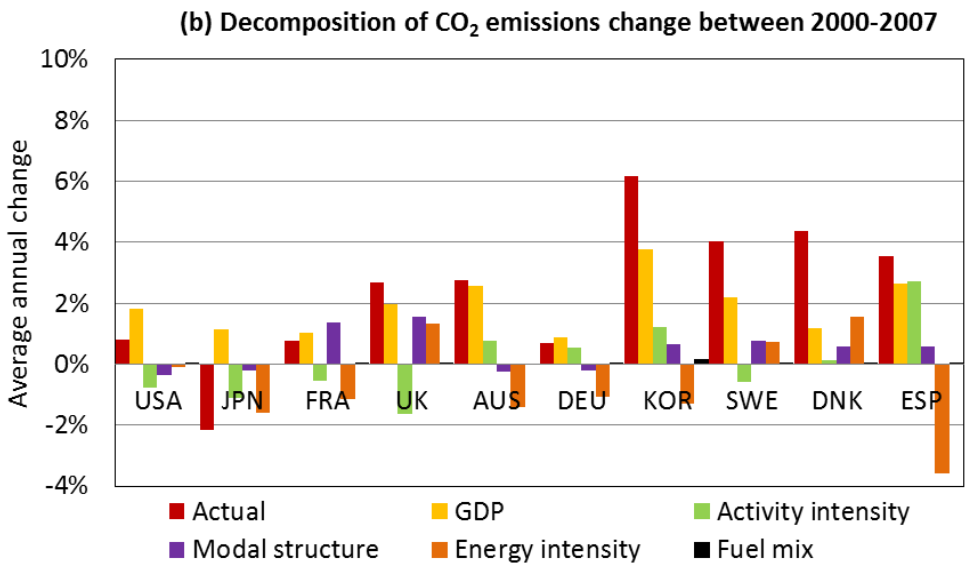
- Trucking is most energy intensive, and its modal energy intensities vary substantially across the countries.
- Countries with the highest aggregate energy intensity is those with energy intensive trucking and low shares of rail and water transport.



Decomposing Freight CO_2 Emissions Change between 1990-2000 and 2000-2007

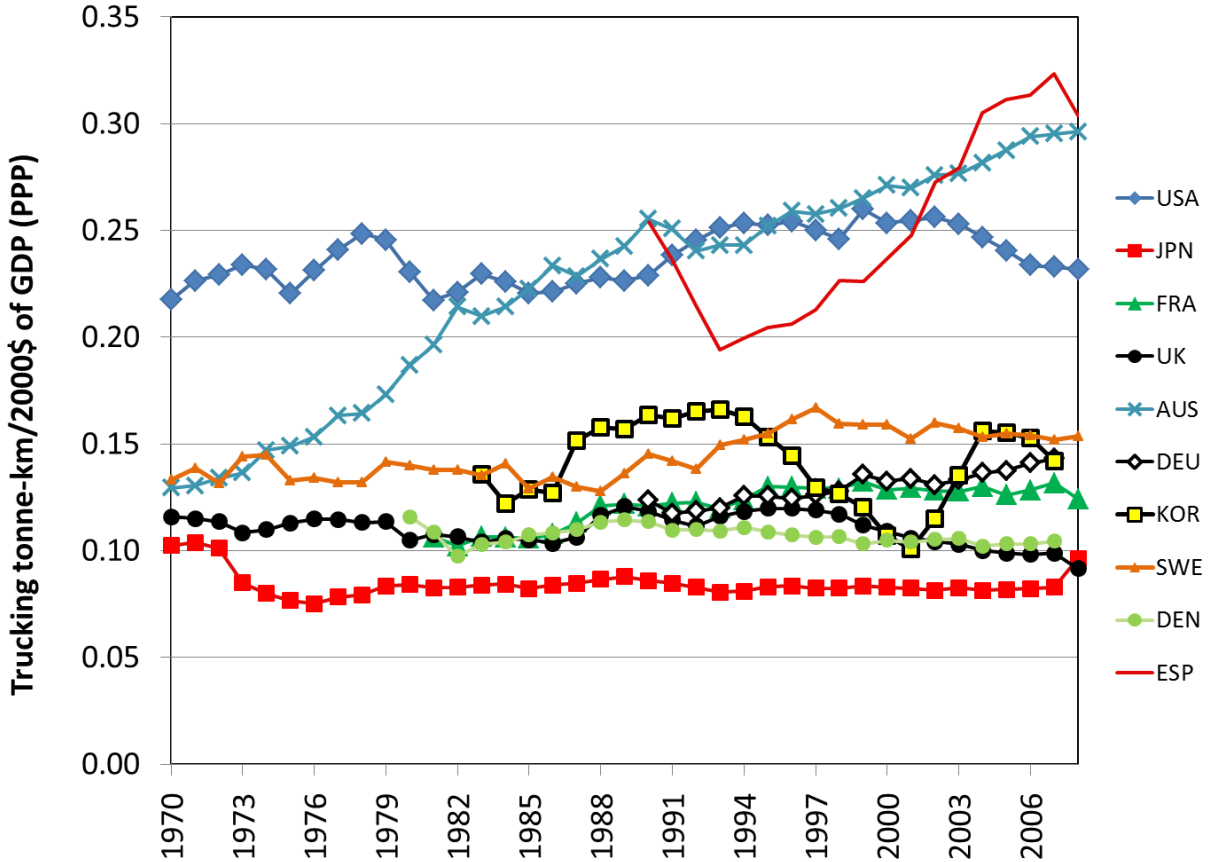
- Freight CO_2 emissions have all increased (except for Japan in the 2000s).
- But, the rate of the increase varied considerably: Large differences in the activity effect (GDP & activity intensity), modal structure, and energy intensity
- The changes in modal structure have put upward pressure on CO_2 emissions: Continued shift toward trucking
- Moderation in the activity effect over the last two decades (except for South Korea & Spain): energy intensity & modal structure became more important.





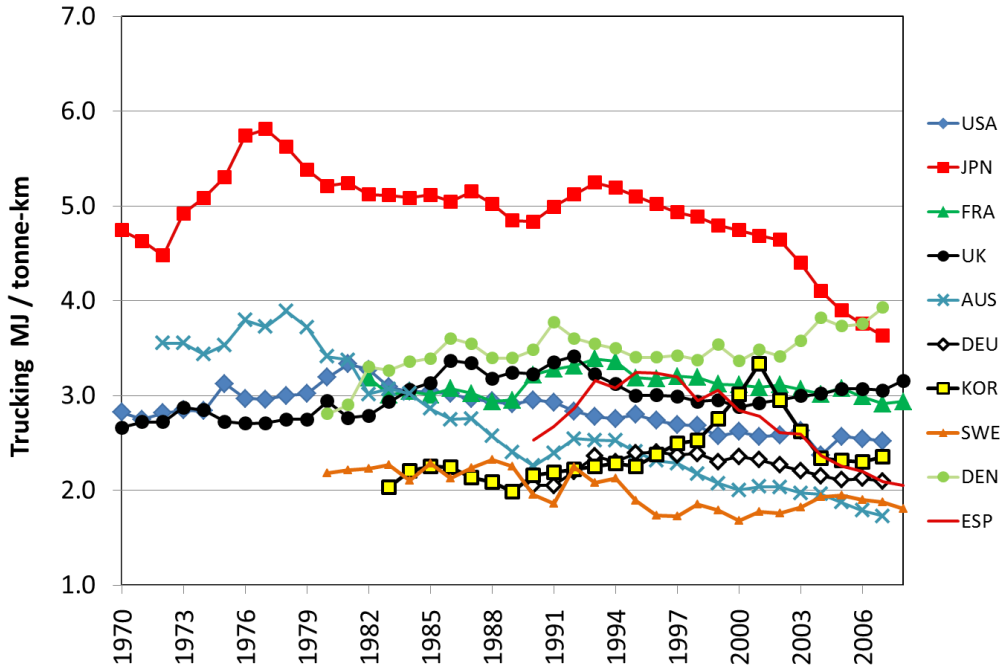
Trucking and GDP

- Intensifying demand for trucking as a part of economic activity, particularly in the large countries (but, in these countries, overall freight activity intensity of GDP has not increased).
- No indication of decoupling between trucking and GDP.
- Spain still under investigation.



Trucking Energy Intensities

- Trucking energy intensity has varied *considerably* across and within the countries (due to the average size of truck, freight load, haulage, fuel prices, and technical and operational efficiencies)
- Several countries present substantially high levels of trucking energy intensity (e.g., Japan and Denmark).
- Australia has experienced substantial reduction in trucking energy intensity because if increased use of 3-trailier "road trains."
- Differences in actual vehicle fuel efficiencies only small part of difference: mainly a function of vehicle size, share of capacity carried and empty hauling



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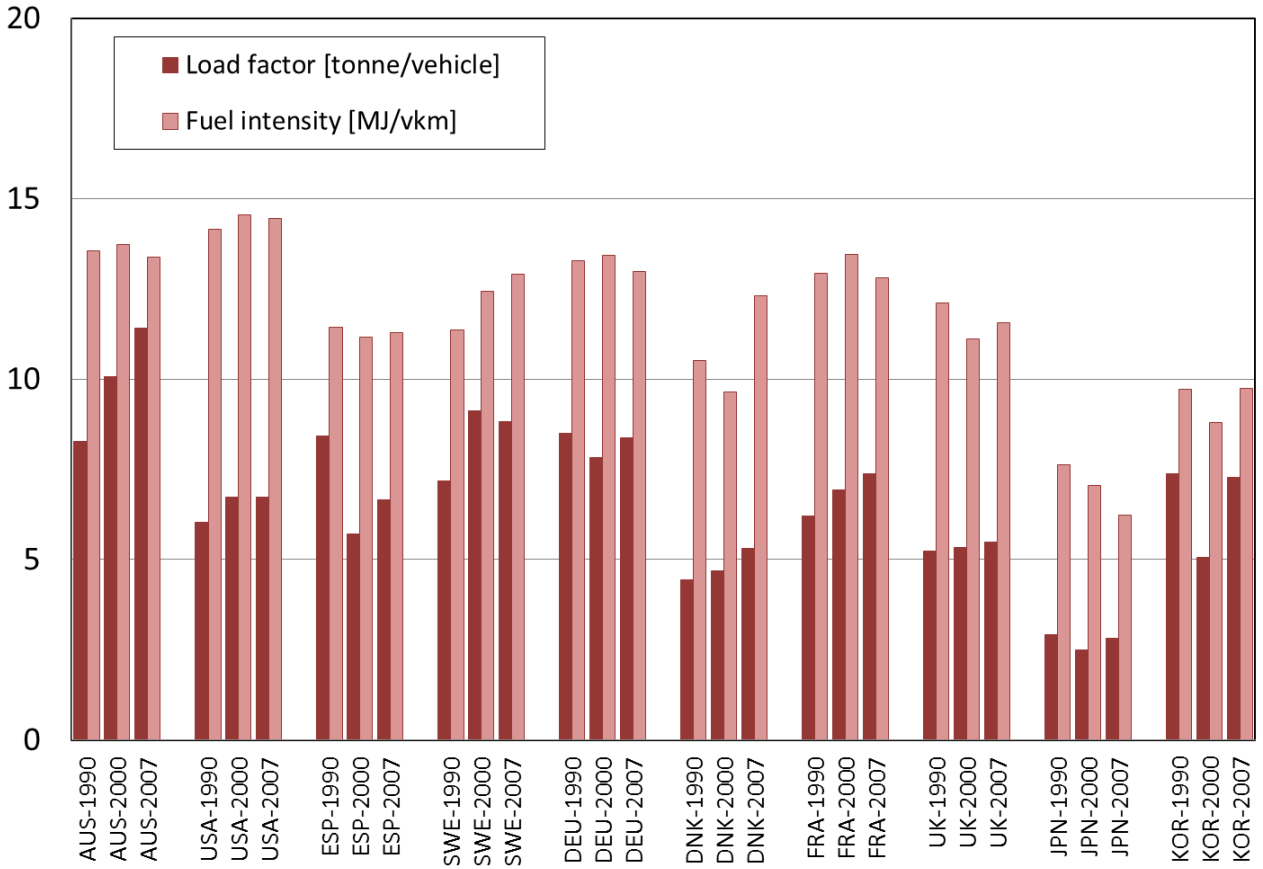
Truck Load Factor and Vehicle Fuel Intensity

- Load factor and fuel intensity [MJ/vkm] have spanned wide ranges
- The overall decrease (or increase) in trucking energy intensity [MJ/tonne-km] involved an increase (or decrease) in trucking load factor.



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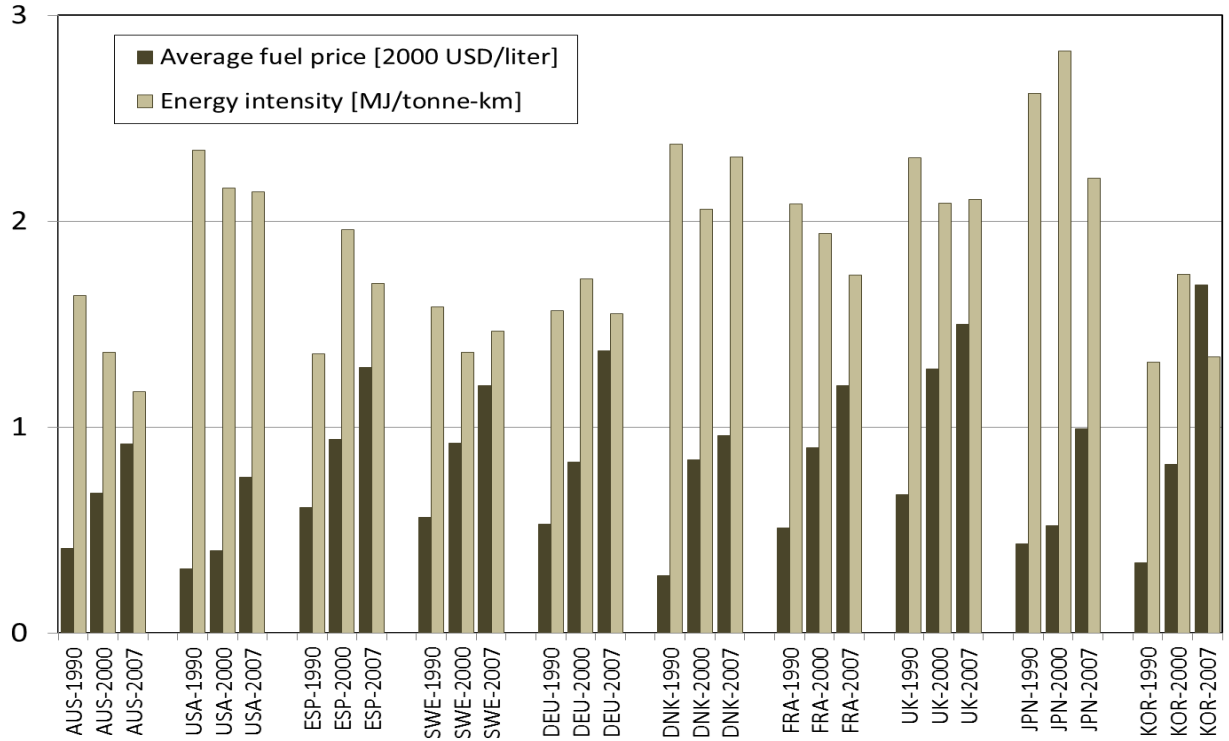
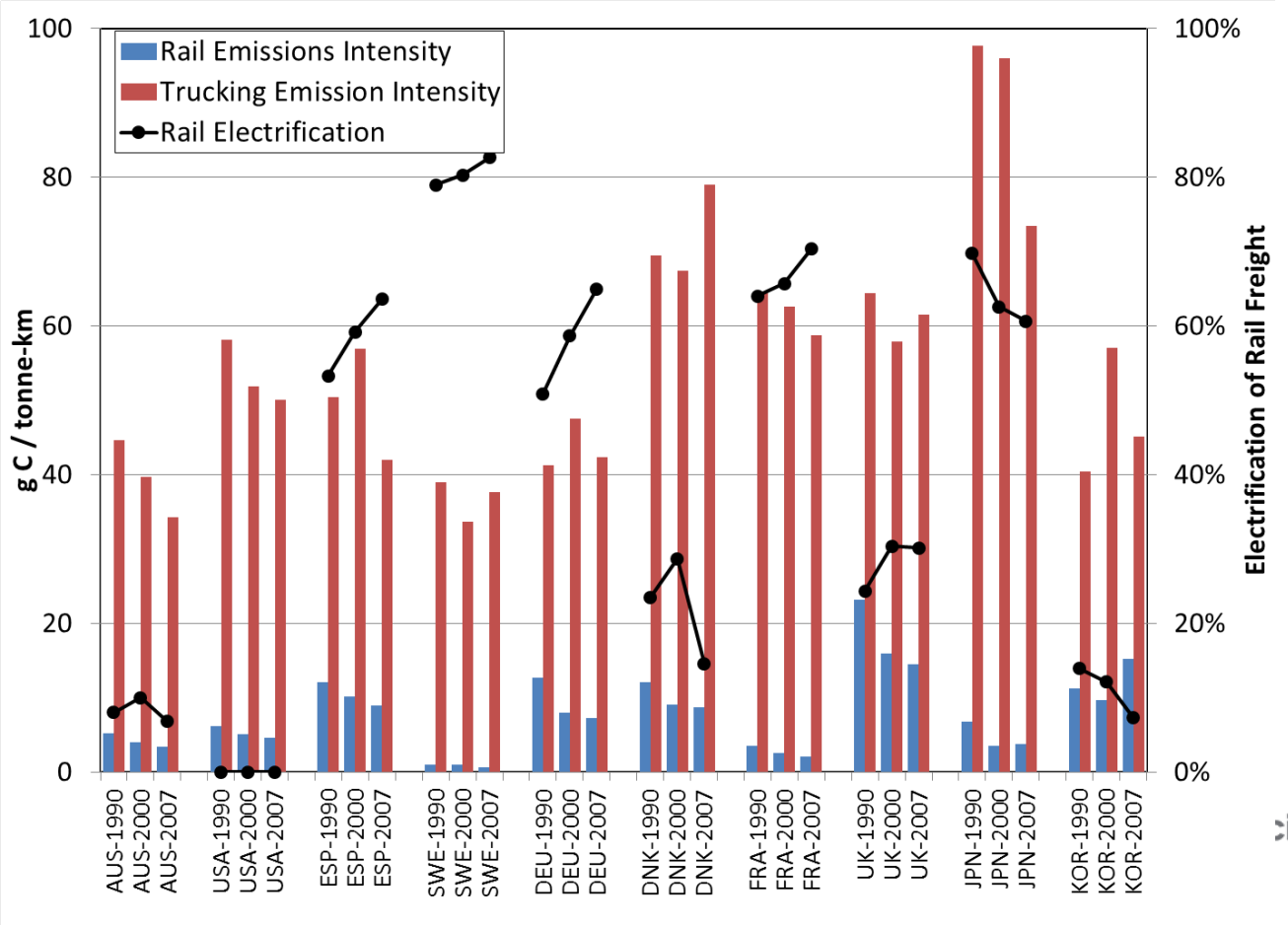
Fuel Price and Trucking Energy Intensity

- Changes in trucking fuel price may have influenced trucking energy intensity [MJ/tonne-km]: the trend in trucking energy intensity is largely correlated with the growth rate in trucking fuel price (particularly in Japan, Germany, Denmark, and Spain)
- Fuel prices appear to influence truck utilization and efficiency, but not modal share.



Carbon intensities of rail and truck freight

- Carbon intensity of rail freight has declined (including CO_2 used in rail electricity used for freight).
- The extent to which freight CO_2 emissions can be reduced from the modal shift toward rail away from truck is very different (depending on rail electrification *and* power sector emissions).



Key Findings

- Various income elasticities of demand for freight service—a function of economic mix, geography, and foreign trade?
- The linkage of freight transport with GDP is reduced as economic structure changes (related to the shrinkage of the industrial sector).
- With the overall moderation in the effect of freight activity on CO_2 emissions, improved management of modal structure and energy intensity has became relatively important.
- Trucking energy intensity of trucking is generally decreasing (possibly due to improved loading and larger vehicles) but
  - Trucking activity has increased faster than other freight activity
  - Still a large cross-country variation in trucking energy intensity
- Modal shift toward rail away from truck gives a big opportunity to reduce freight CO_2 emissions, and the gain varies across the countries. Road congestion in many countries may be driving force.

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Discussion

- Ongoing transformation in the global economy
  - Potential freight emissions leakage
  - Importance of improved freight technology, logistics, and planning in the developing world.
- Reducing Trucking CO_2 Emissions?
  - Better loading, logistics, and technical improvement
  - Policies (tech or loading standards, CO_2 tax)
  - Low carbon fuels such as biofuel and electricity
- Railway as a clean substitute?
  - Rail electrification may not always be good: it reduces the energy intensity of rail freight but is likely to increase the carbon intensity of rail energy, unless the power sector is de-carbonized.
  - But, modal shift toward rail away from truck still gives a big opportunity of reducing freight CO_2 emissions.
  - Yet, substantial modal shift back to rail is not likely in the short term.

QUESTIONS & COMMENTS?