On Containing CO_2 Emissions in International Ocean Transportation: Some thoughts on the Case of Slow-Steaming

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Climate Change Impacts on International Transport Networks

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ABSTRACT With its immediate link to trade, ocean transportation, together with ICT, is one of the pillars of globalization. As a result of its international character, shipping is one of the least regulated industries known and one of the last to adopt the principles of Corporate Social Responsibility. Expanding trade, and as a result an expanding world fleet, raise serious concerns on the environmental impact of transport operations particularly as regards GHG emissions. The issue needs to be addressed at an international level through the proper mix of regulatory measures and induced market mechanisms aiming to balance environmental costs with benefits from trade and economic development. The paper explores the case of *slow-steaming* through a statutory limitation of sailing speeds. Although substantially more research needs to be carried out, preliminary results show that, under current fuel and ship prices, this could be an effective and immediate step to curtail emissions in the short run and lead to energy-efficient ship technologies in the longer term.

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- Environmental impact of shipping
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The significance of the international ocean transportation industry

Due to the morphology of our planet, more than 90% of global cross-border trade is carried by sea.

Together with Information and Communication Technologies (ICT), international ocean transportation is a pillar of globalization.

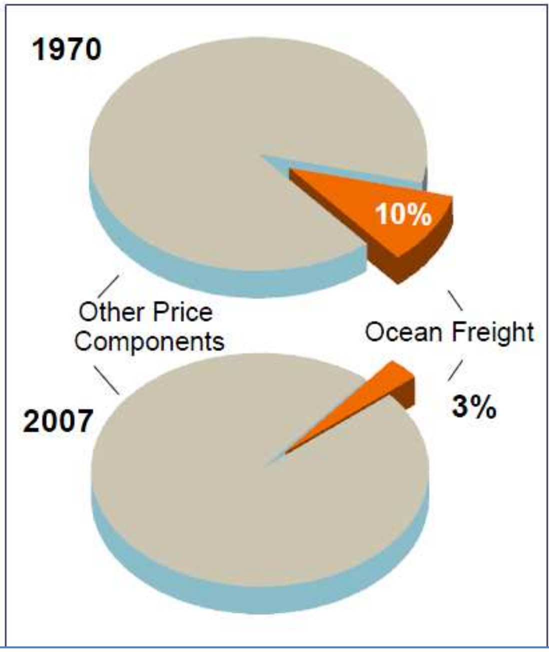
Due to technological progress, competition and economies of scale, ocean transportation has reduced transport and trade costs to such an extent as to make 'distance' an almost irrelevant factor in the trading decisions among nations.

Ocean transportation does not only facilitate trade but it equally well creates it: low transport costs enable countries to trade with each other in ways that would be unthinkable only a few decades ago.

These facts, and the importance of ocean transportation for the 'global village', are fairly unknown to the wider public who only comes to rudimentarily explore them whenever a maritime accident or environmental disaster takes place that catches the attention of the media.

Economies of Scale, competition and rationalization have lowered transport costs substantially

(significant differences exist however between regions and countries)



Price Components Motorcycle

	Retail Price	Ocean Freight	Share
1970	$5,000	$500	10%
2007	$3,000	$90	3%

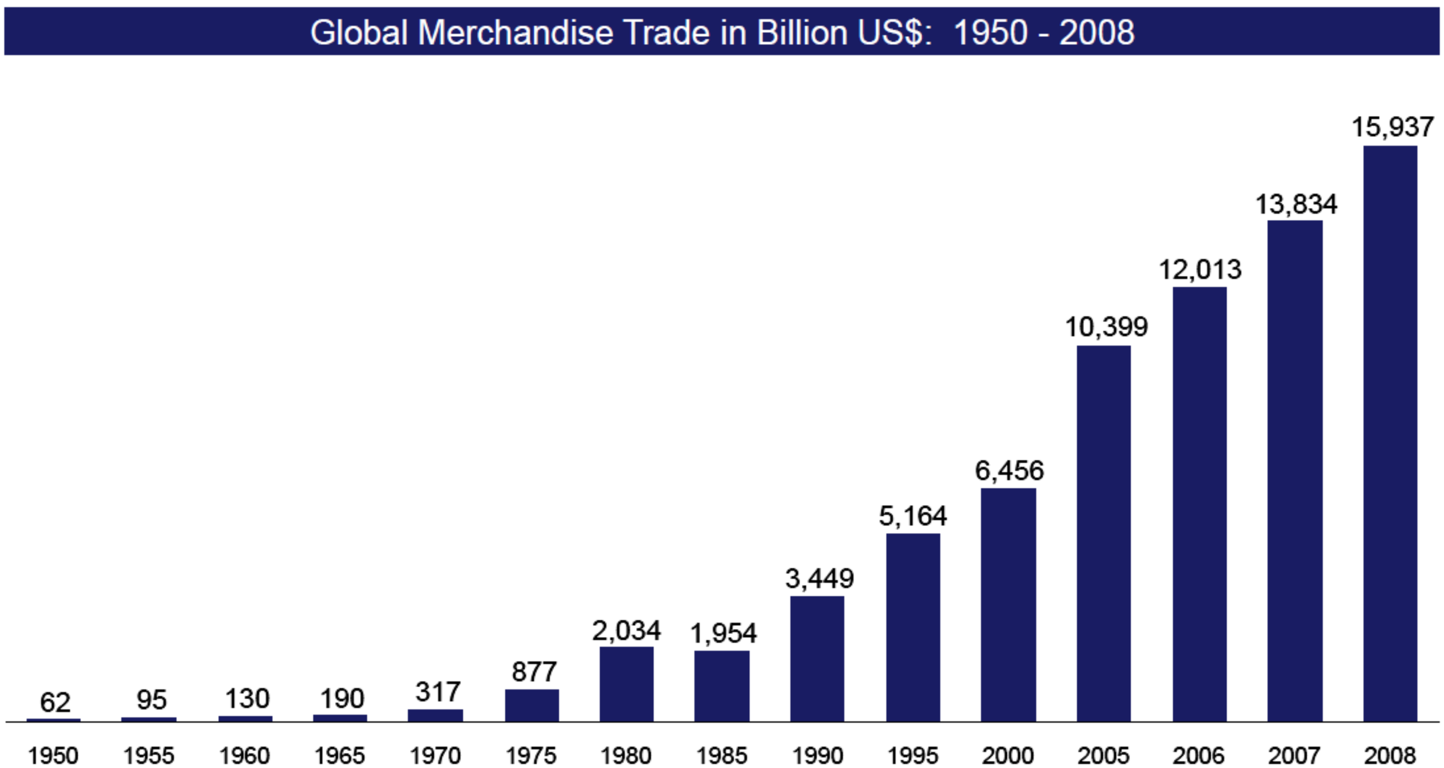
Typical Ocean Freight Levels 2007

	Retail Price	Ocean Freight	Share
Television Set	$500	$10	2%
Vacuum Cleaner	$75	$1	1%
Beer (1Bottle)	$1	$0,01	1%

Source: MEL and various

Development of World Trade

Expanding trade, and as a result an expanding world fleet, raise serious concerns on the environmental impact of transport operations particularly as regards GHG emissions. Research shows that a 1% increase in trade leads to a 0.58% increase in CO_2 emissions. The situation is accentuated by developments in global logistics and hub-and-spoke systems.



Source: WTO

Environmental Impacts of Logistics

frequency of service, minimization of inventory costs, and JiT production-transport-distribution systems lead to:

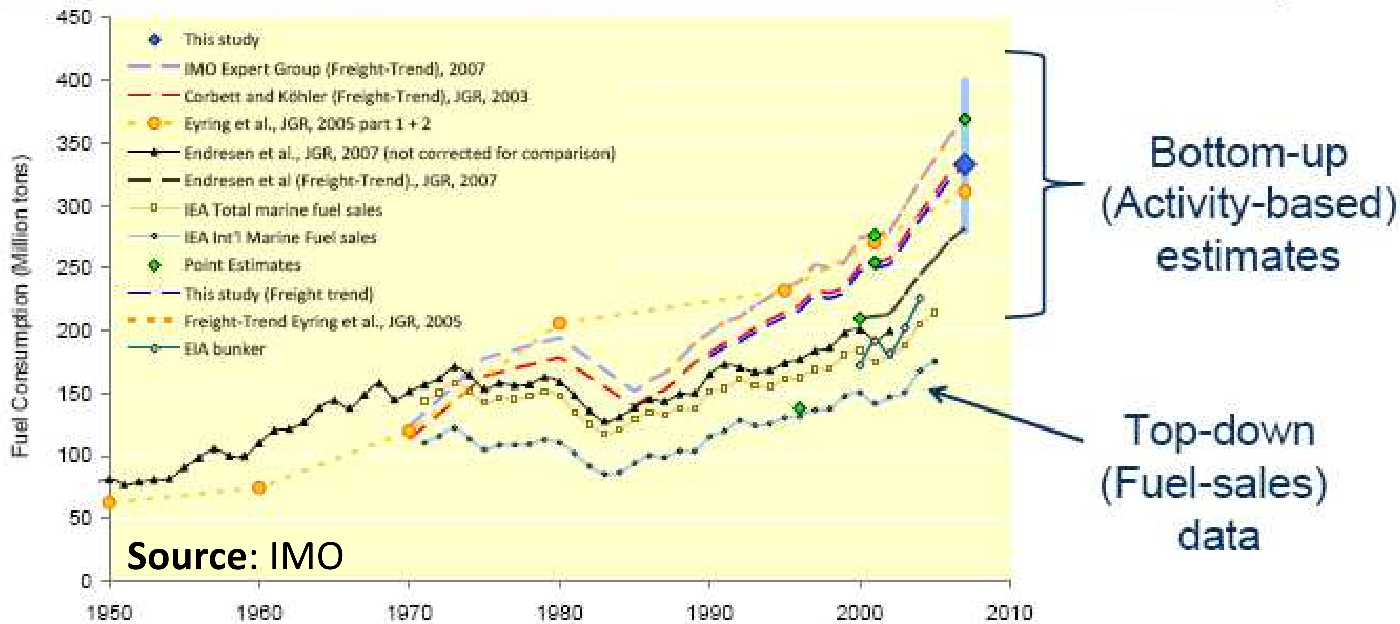
- Transport-intensive operations
- Low capacity utilization of transport means
- Low energy efficiency (gCO_2/t-km)
- High demand on (limited) road infrastructure
- Congestion
- Demand on (prime) land with alternative uses (distribution / dry ports)
- Concentrated air pollution, noise, dust, vibration, visual intrusion at hubs and distribution facilities

Through the right mix of policy interventions, policy makers need to rebalance the need for economic efficiency (frequency and low inventory costs) with the external costs logistics impose on society.

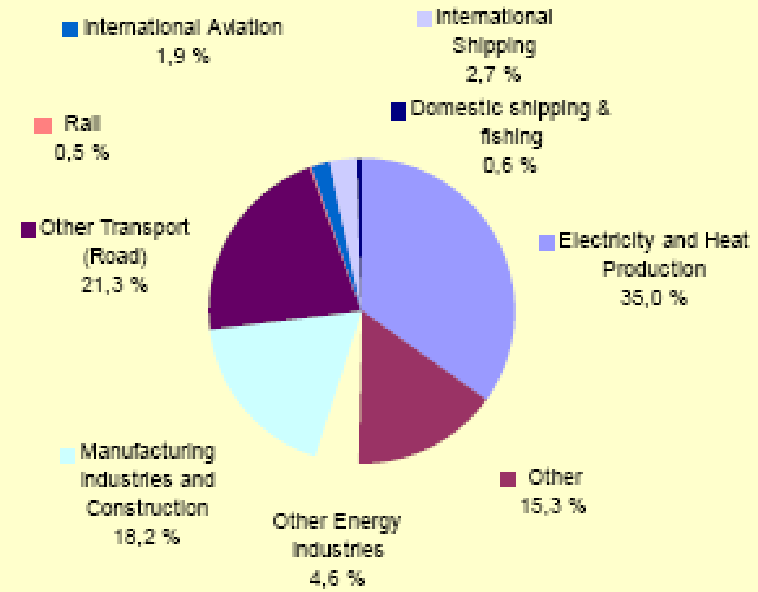
According to OECD, global CO_2 emissions from maritime transport have almost tripled in the period 1925 – 2002. Ongoing research preliminarily shows that, if left unchecked, maritime transport might double or even triple its emissions by 2050, particularly if the development path and transport demand projections of China and India are taken into account.

World Fleet Fuel Consumption

2007	Low bound	Best	High bound
Total fuel consumption	279	333	400



CO_2 Emissions from International Shipping Compared to Total Global Emissions from other Sources

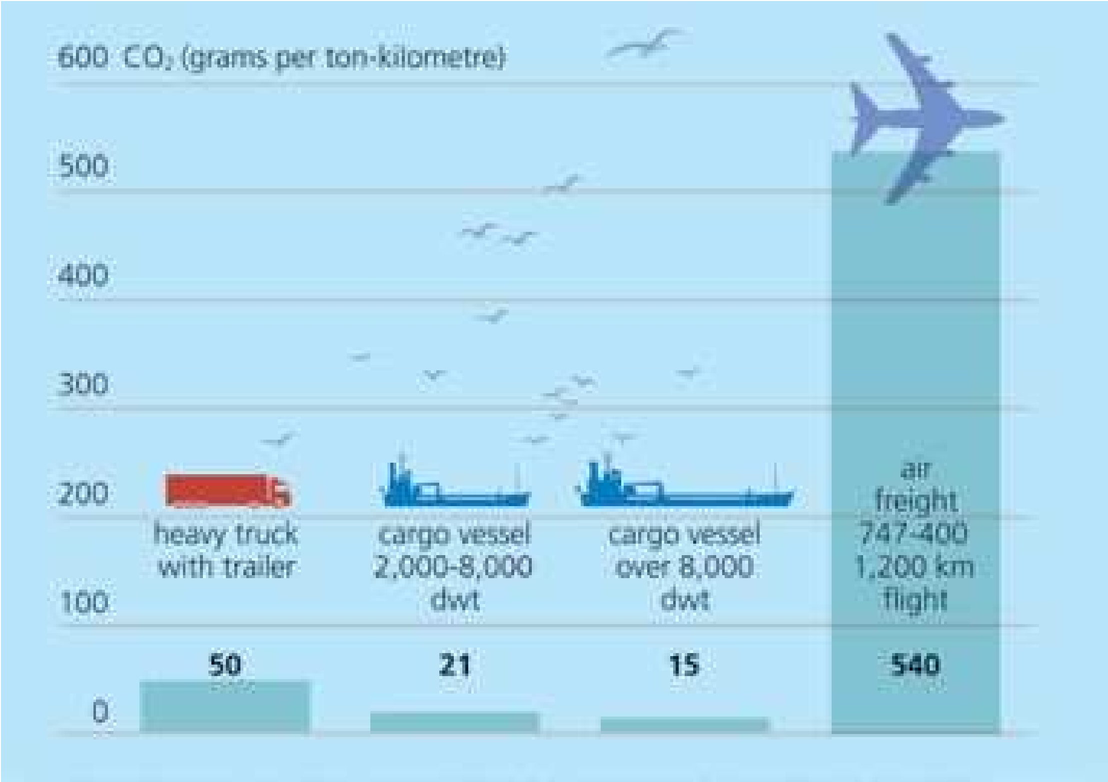


Source: IMO

In 2007, international shipping consumed 2-3% of fossil fuel and emitted 870 million tons of CO_2, representing 2.7% of global emissions. Although, at first sight, this may not look worrisome, this amount of emissions exceeds by far the GHG emissions of Germany.

CO_2 Emissions by Mode of Transport

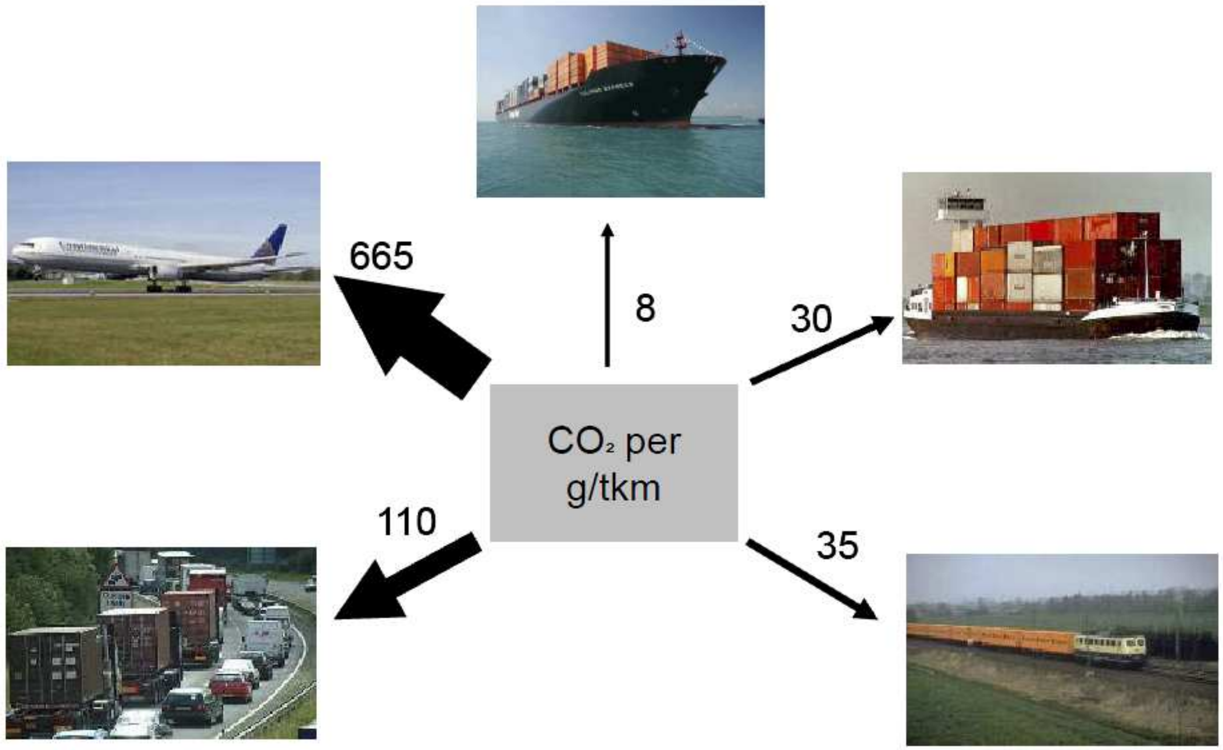
comparatively however shipping is the most energy efficient mode of transport



Source: NTM (Swedish Network for Transport and the Environment)

Ocean transportation: the most energy efficient way of transporting goods

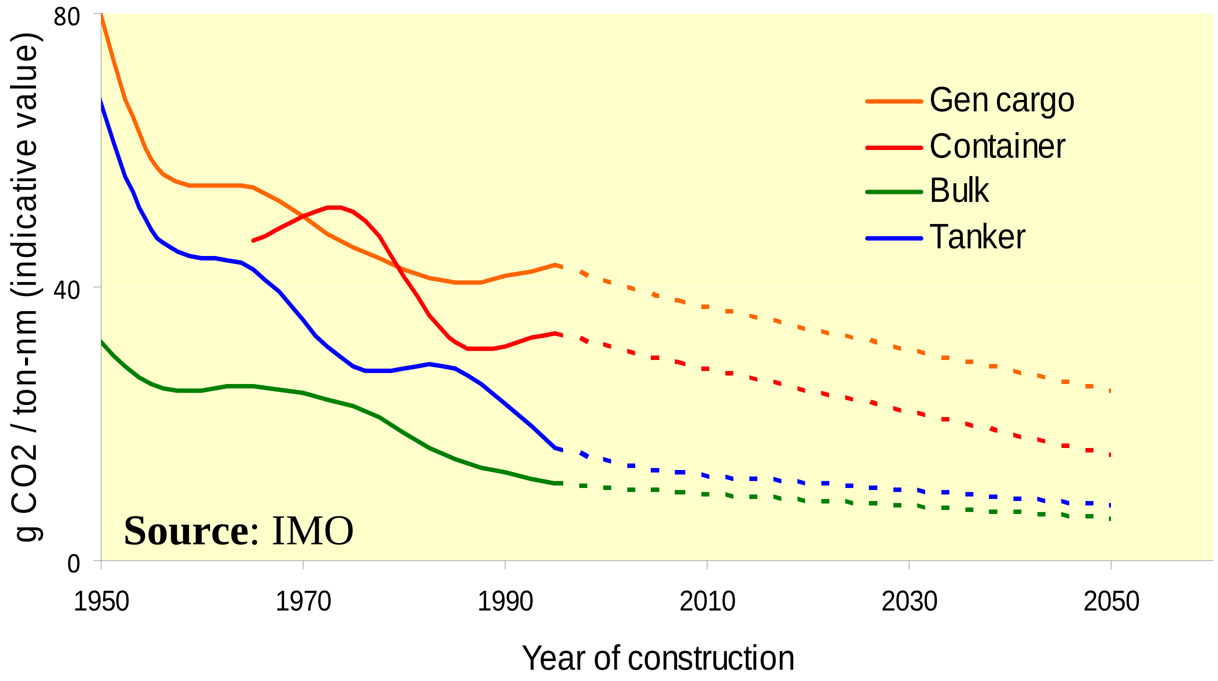
(CO_2 Emissions per mode of transport)



Source: IFEU – Institute and Hapag Lloyd

Environmental performance of shipping

(Technology has not been so 'inconsiderate' after all, but much more is needed)



REGULATORY STEPS, MARKET-BASED INSTRUMENTS AND PRIVATE INITIATIVES

- The IMO Energy Efficiency Design Index (EEDI)
- The IMO Energy Efficiency Operational Indicator (EEOI)
- Ship Energy Efficiency Management Plan
- Cap-and-Trade Schemes and Carbon Levies
- Environmental Shipping Index
- Ecoports

The IMO Energy Efficiency Design Index (EEDI)

This *ex ante* (technical) Index, to be probably made mandatory under MARPOL, consists of a complex formula of factors meant to guide the shipbuilding industry towards developing ship designs and actual vessels of high energy efficiency and minimum GHG emissions. In the short to medium term, progress is expected towards more fuel-efficient hull; engine; propeller and rudder designs. A threshold will most likely set a limit to emissions, according to ship type and size. It is likely that emissions trading may be based on this Index.

$$EEDI = \frac{Environmental\ costs\ to\ society\ (emissions)}{Benefits\ for\ society\ (ship\ type\ and\ CCC)} (gCO_2 / t - km)$$

The paramount aim of the EEDI should however be to balance the insatiable appetite of naval architects for innovation, with the need of society for low transport costs, more trade and welfare.

The IMO Energy Efficiency Operational Indicator (EEOI)

•This *ex post* (operational) Indicator and the accompanying Guidelines are meant as a voluntary step. The aim is to assess operational efficiency of existing ships through benchmarking with industry best practices. If efficiency results are properly reported and publicized, through carriers' individual marketing efforts, it is believed that the Index could be an excellent incentive, encouraging carriers to strive towards their efficiency frontier.

$$\text{Fuel Consumption Efficiency Index} = \frac{\text{Fuel Consumption in Operation}}{\text{Cargo Onboard} \times (\text{Distance traveled})}$$

Ship Energy Efficiency Management Plan:

This is an onboard 'best practices' environmental guide on improving:

- **Voyage planning** (weather routeing / just-in-time)
- **Speed** (and, thus, fuel consumption)
- **Fleet management** (minimize ballast legs)
- **Cargo-handling** (better planning and information exchange with ports to minimize waiting at ports as well as sailing speeds for JiT arrival; an issue becoming increasingly important for bulk carriers and terminals)

The Guide will have voluntary nature, it will be developed in close collaboration with the shipping industry, and aims at providing ship operators with practical advice as to the technical and operational means to make their ships more environmentally efficient.

Source: IMO, MEL, and Cullinane

Emissions Trading and Fuel Levy Proposals

Both systems are subject to heated debate. Both are technically and politically difficult to implement with international accord. Pertinent questions include:

- General applicability to all ships? (energy efficiency incentives, link to EEDI)
- General applicability to all countries? (evasion concerns)
- Applicability to all modes of transport? (modal shift and distortion of competition)
- Free tradability of emissions credits? (within transport and/or other industries)
- Cost effectiveness and impact on world trade?
- Effect on promoting Research and Development on energy efficient technologies?
- GHG fund administration and allocation of revenues? (IMO; developing countries; R&D)
- Retroactive application? (credits to energy-efficient stakeholders)
- Determination of the level of the levy and trading cap?
- Consequences of non compliance? (e.g. shortfall in emissions credits)
- Credible and convincing monitoring and reporting?

Cooperation, information exchange and more research are required to, successfully, move forward

- The multitude of stakeholders in the supply chain (carriers; ports; hauliers; etc.) are badly informed about the ramifications of climate change on their operations.
- They are equally badly informed on the impacts of measures in some other components of the supply chain on their own operations. A holistic approach is thus required.
- Although substantial monies (US $ 100 bn to 2020) have been promised in "Copenhagen" to assist developing countries with their mitigation and adaptation efforts, these funds might not be automatically forthcoming, and policy-making may drag its feet in perpetuity, unless there is general conviction on the effectiveness of these efforts.
- It is the responsibility of policy makers to inform and convince the global society that the long-run marginal cost of mitigation and adaptation (including trade effects) is equal to the marginal benefit of greener shipping and ports, now and in the future.
- In addition to regulatory and market based measures, this will require international cooperation and exchange of information on 'best practices' (for instance similar to the *ecoports* initiative), but above all it will require more research, such as this of the following slide.

Examples of 'convincing' research

STARTLING RETURN ON INVESTMENT

- The American Environment Protection Agency (EPA) has calculated the financial benefits of the US Clean Air Act: The estimated monetised benefits in the period 1970-1990 from reductions in mortality; chronic bronchitis; lost IQ; hypertension; hospital admissions; respiratory-related problems; soil damage; visibility; and agriculture exceed **$ 20 trillion**.

- By contrast, compliance costs – cleaner air, water etc. – totaled $500 billion over the same period. The EPA's cost/benefit estimates for the 1990 Clean Air Act amendments, aimed at combating acid rain, ozone destruction and other air pollutants, are forecast to be equally beneficial in financial terms.

The significance of cooperation and information exchange in creating a common awareness of environmental challenges

The Top-10 Port Environmental Issues (*Ecoports* Foundation and ESPO)

1. Port waste management
2. Dredging
3. Disposal of dredged materials
4. Dust
5. Noise
6. Air quality
7. Bunkering
8. Hazardous cargo
9. Port development (land issues)
10. Discharging of cargo

Environmental Shipping Index

- This 'Rotterdam' initiative originated from the World Ports Climate Initiative and has the support of the International Association of Ports and Harbors (IAPH) and the European Seaports Organization (ESPO).
- Ships may obtain an ESI grade by reporting on verified engine certificates; bunker fuel information; and CO_2 emissions. The grade is based on a 'credits' system for performance above IMO baselines for NOx, SOx, PM, and CO_2 emissions.
- Following this, cooperating ports may offer generous rebates on port dues.

Speed and Fuel Consumption

Fuel consumption increases exponentially with speed:

$$Cs = \left(k \big/ T^3 \right) \cdot d^3$$

However, the societal costs of higher speeds, in terms of CO_2 emissions, outweigh by far the commercial benefits derived from it, particularly as international shipping is in principle a tax-free industry.

Obviously ocean transport externalities are not internalized in the price of the transport service, and the fundamental question of balancing public and private interest needs to be addressed.

Slow-steaming: thoughts and ensuing research questions

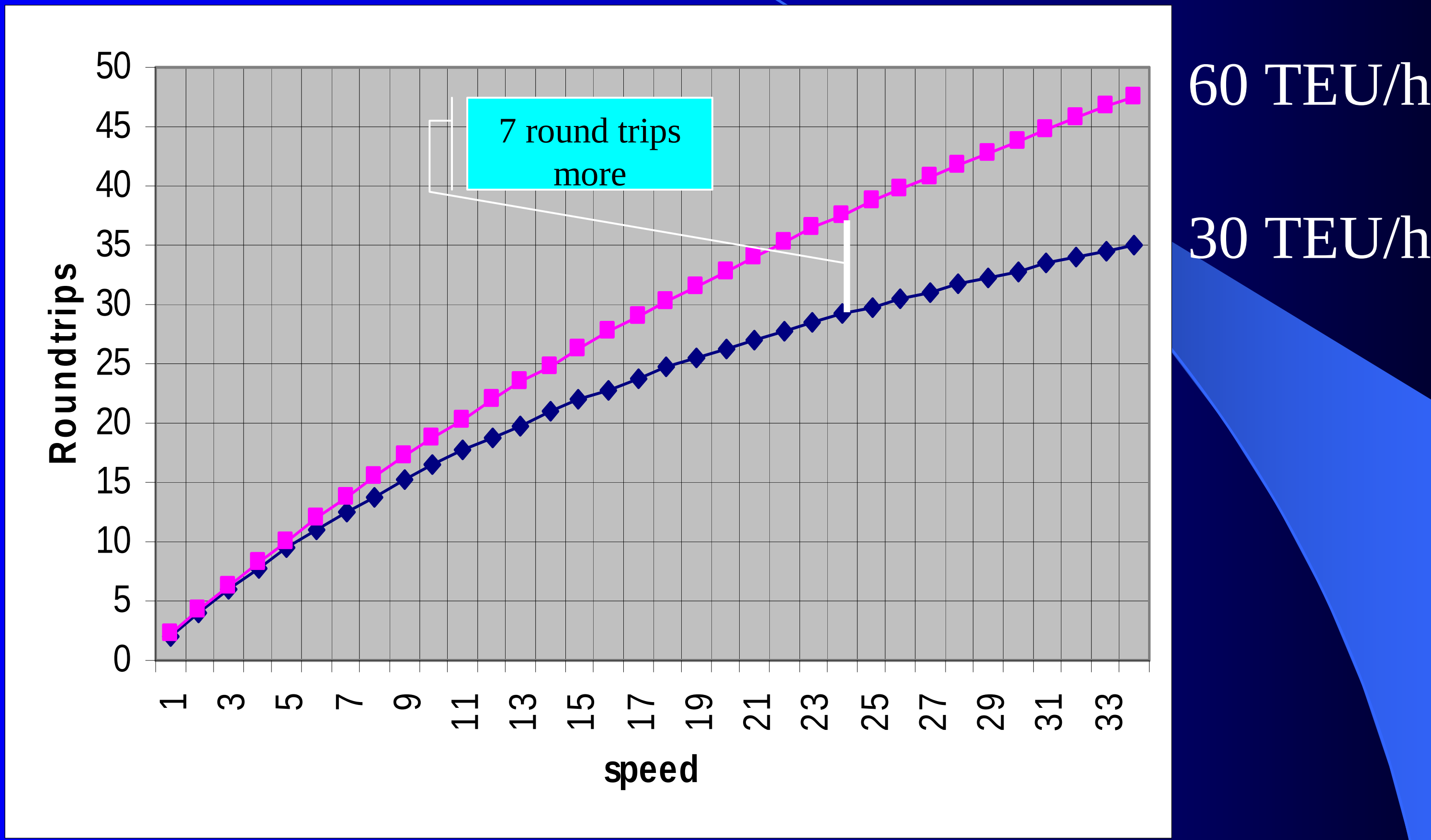
A statutory limitation in sailing speeds is bound to have an impact on ship productivity and effective short-term supply of tonnage.

With a growing demand for shipping services, a supply shortfall would consequently, in the short-run, lead to higher freight rates (transport costs) and –at least in theory- less ‘real income’ and consumer surplus.

Trade volumes however are shown to be highly inelastic to variations in transport costs and trade itself will be little affected.

Productivity: Impact of Speed on Effective Supply

(round trips per year of a 1000 TEU feeder ship over a distance of 2000 nm)



With port productivity at 60TEU/h, a reduction is speed from 25 to 14 knots results in 12 round trips less per year.

Slow-Steaming and Transport Costs

If there is an impact of slow-steaming on transport costs (and this needs yet to be researched) due to Demand-Supply imbalance, this would in principle be only temporary:

Improved freight rates will lead to new investments in ships that will now use energy-efficient technologies as prescribed by international regulation and environmental standards (e.g. IMO's EEDI).

Both physical and effective supply will therefore again rise (and transport costs fall), but this time through the addition of energy-efficient ships.

Moreover, with intensified competition in shipping markets (abolition of conferences in Europe, etc.) it is at least equally likely that any increases in transport costs are absorbed in profits rather than passed on to consumers.

Impact of Slow-Steaming on Bulk Trades

The impact of reduced speed on bulk trades is expected to be minimal. The transportation of bulk goods (oil, coal, iron ore) has no urgent character and is mostly undertaken for stockpiling purposes.

Speed is thus of no significance and this explains why tankers and bulk carriers sail at much lower speeds (15 knots) than containerships (25 knots).

The price of row materials and agricultural exports might however increase and, were this to happen, the impact would be especially felt by developing countries in the short run.

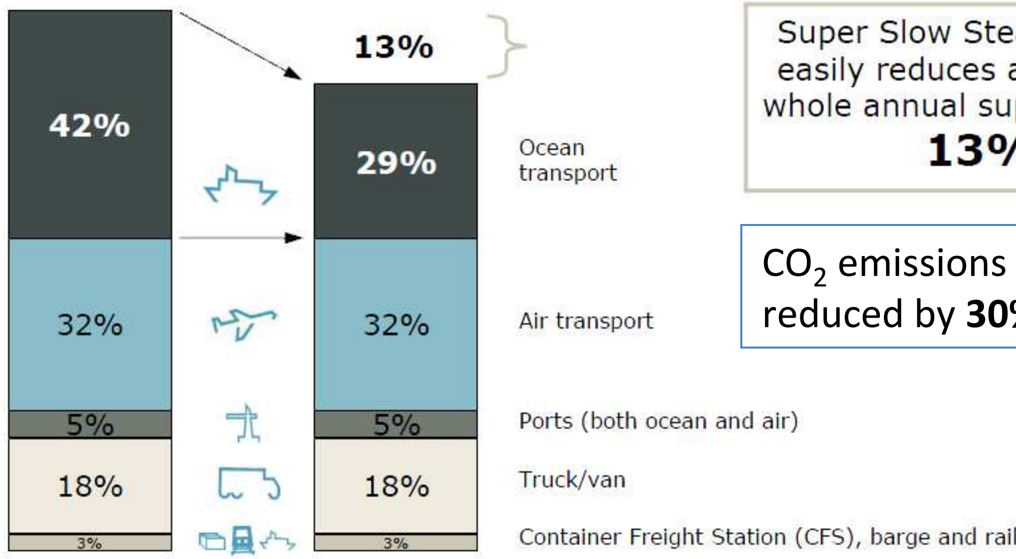
Impact of Slow-Steaming on Liner Trades

Assessing the impact of slow-steaming on liner trades is far more complex: If not compensated with the addition of extra ships in networks, slow-steaming will affect frequency of service; inventory levels and costs; distribution activities; ports of call; and supply chain costs in general.

On the positive side –and pioneering research is carried out at Erasmus University on this- lower speeds use the 'ship and the sea' as inexpensive 'warehouses' thus relieving pressure on the more expensive (and environmentally sensitive) land. Distribution networks need to be redesigned of course, but preliminary results show that the end effect would be lower supply chain-, as well as environmental costs.

Finally, as the following example demonstrates, savings on fuel (as well as environmental impacts) outweigh by far the cost of adding extra ships to itineraries (under current fuel and ship prices).

Effect of slow-steaming on supply chain costs and customers' carbon footprint



Super Slow Steaming alone easily reduces a customer's whole annual supply chain by **13%!**

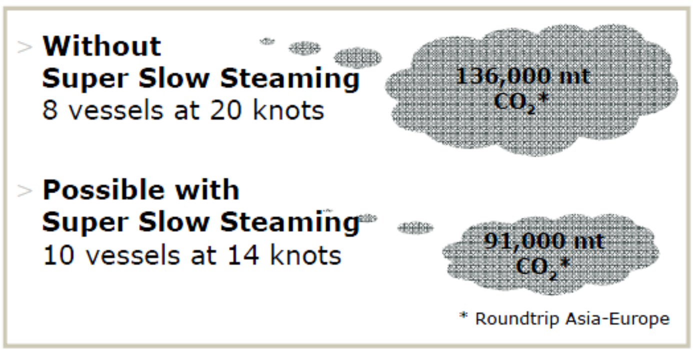
CO_2 emissions are reduced by **30%!**

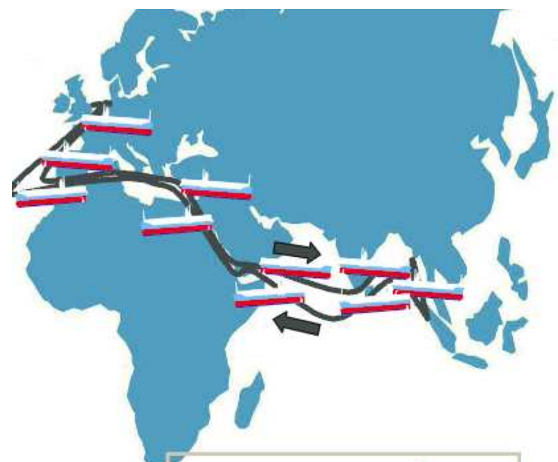
Source: Maersk Line

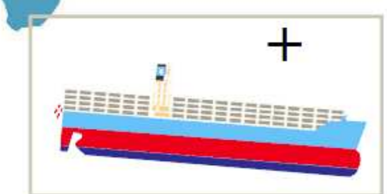
The example refers to large American retailer also distributing in Europe: From Asian CFS or port to regional distribution centers in Europe over the course of one year. 30% CO_2 savings.

Super Slow Steaming: Add a Vessel, Save Fuel

A weekly Asia-Europe service, at a speed of 20 knots, requires 8 vessels. With super slow steaming (14 knots) one or two additional vessels would be necessary. At current fuel prices; price of vessels; productivity at ports; and ship engine efficiency, the savings from fuel consumption outweigh the costs of extra vessel(s). Carbon emissions are at the same time reduced by 30%. In most cases, this allows for more port calls, thus shortening supply chains; reducing transshipment; hinterland (road) transport and related costs and environmental externalities.





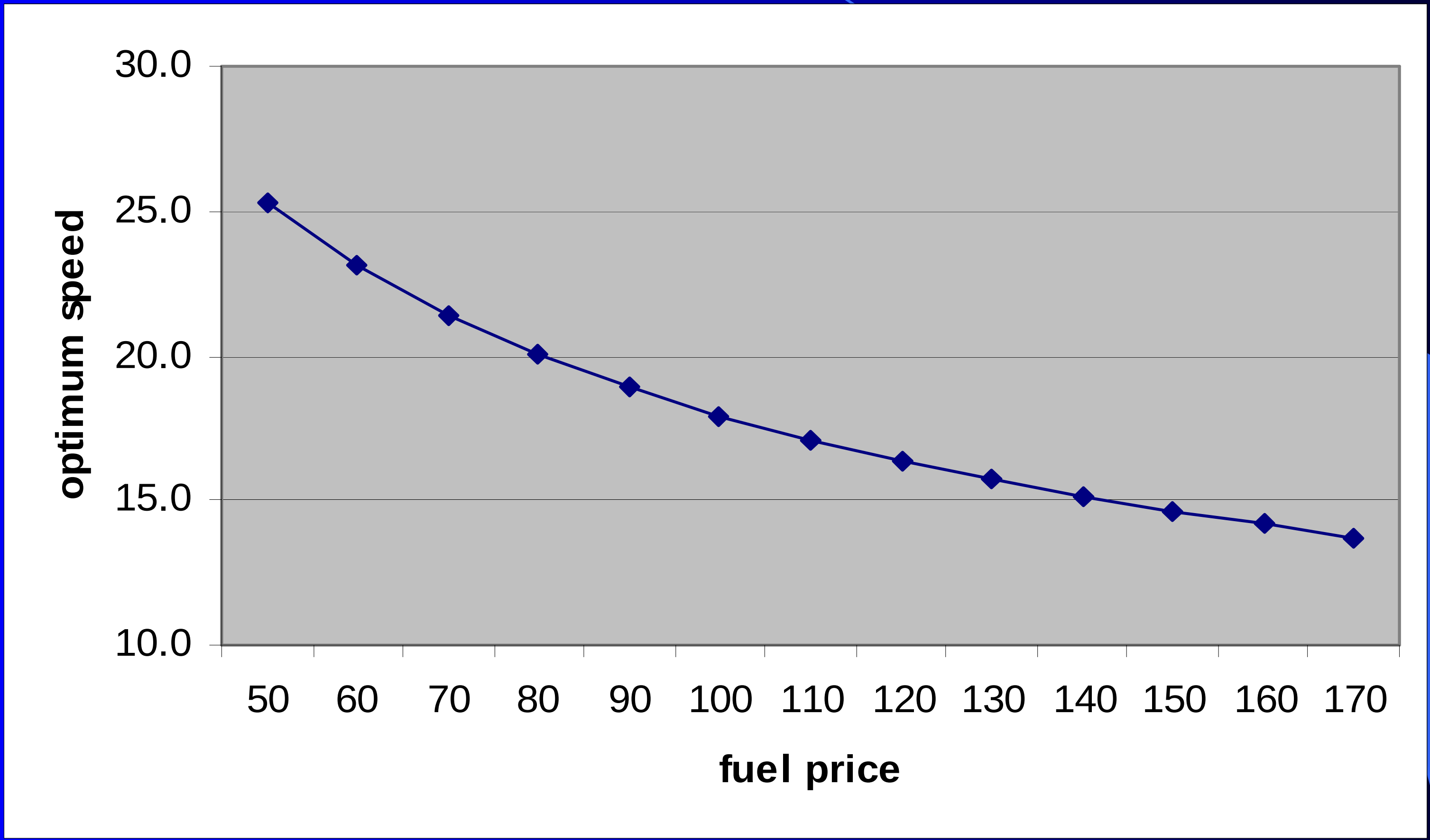


$$\bar{S} = \frac{d}{T} = \sqrt{\frac{f}{3pk}} \quad \text{(optimum speed)}$$

$$n = \frac{A}{2\left(\frac{d}{s} + \frac{2Q}{r}\right)}$$

Emission calculations: Maersk Line

Slow Steaming: Optimum Speed as a Function of Fuel Price ($/ton)



European feeder service; calculations MEL-Erasmus

Conclusions

- In view of its multifaceted international character, shipping has so far been one of the least regulated industries known and one of the last to endorse the dictates of Corporate Social Responsibility.
- This picture is rapidly changing and various regulatory; market-based; and private initiatives are already in place or being considered.
- Amongst them, this presentation has argued, a statutory limitation of sailing speeds could be an effective and immediate step to curtail emissions in the short run and lead to new ship investments of higher energy efficiency according to statutorily determined standards.
- Scenario analysis and simulation research is currently underway at MEL, to measure the effect of fuel and ship prices on sailing speed decisions, as well as the impact of the latter on shipping networks ; ports of call; freight rates; distribution and inventory costs; and ship investment decisions.

Regulation is necessary to correct failing markets. However, nowadays, markets are equally necessary to help out ineffective regulation.

Shipping is the best example.

Thank you for your attention