International maritime freight

Marine contribution to climate change

Domestic coastal shipping produces about 3% of carbon from UK transport sources[i]. This does not include international shipping. Globally, such shipping may produce between 1.8% and 3.5% of greenhouse gases but the picture is complicated by the use of a particularly impure form of fuel oil. This produces so much sulphur dioxide that this reflects sunlight in the wake of the ships, producing localised ocean cooling. This is a relatively small effect, but is sufficient to balance out the warming produced by CO2 and NOx emissions from the ships' engines. However, while average warming effects are negligible, climate change effects are still strong, because the cooling is very local and the warming is global[ii]. Shipping overall is growing steadily, in line with increases in global trade.

The temperature variation problem will decrease in future because low sulphur fuels are being introduced through international agreement[iii] and the cooling effect will thus be reduced. However, the warming effect will remain and shipping will become a positive net contributor to global warming overall. The low sulphur policy is on grounds of damage to the environment, which is also caused by the use of the low grade fuel oil. This is so viscous that it has to be pre-heated before it is burned and produces particulates as well as NOx and CO2. Attempts are also being made to reduce NOx emissions.

Sensitivity of maritime freight to oil price

As the cost of fuel changes, the cost of international freight movements will rise or fall in price. This will in turn affect where in the world goods are produced in relation to where they are purchased and used. Fuel is not the only cost but is significant and rising.

In fact, the sensitivity of maritime shipping costs to fuel costs has increased rapidly in recent decades for several reasons.

Changes in the nature of deep sea shipping

The first is that ships now spend less time in port, due to containerisation and faster, mechanised loading and unloading. This has increased the importance of at-sea costs which include a larger fuel element.

Secondly, ships have been designed to travel faster and this has increased the tonnes carried per ship per year, making better use of their high initial investment. Financing trade becomes cheaper, because goods are in transit for less time. However, this has meant a fuel penalty. This was accepted because the cost of fuel was low compared to the capital cost of the ship and crew costs.

Finally, the removal or reduction of many import tariffs through world trade agreements has meant that imported goods have become cheaper, but that the cost of transporting them long distances has become a higher proportion of the final price.

Impact of the oil price rise: short term

Understanding the fuel cost element

There are three main elements in the cost of shipping – hiring the vessel, the fuel price, and the port charges. In recent times the charter rates and the port charges showed wide variation with the fuel relatively cheap and stable. For example, discharging oil in a European port could cost between $0.66 and $1.84 per tonne[iv]. Ports will set prices to attract traffic.

The cost of chartering a ship depends a great deal on the demands of global trade relative to available fleet capacity. In relation to the latter, building new ships clearly takes some time. To illustrate this pricing issue, hiring the largest dry cargo ocean vessel (Capesize) was about $30,000 a day in 2004 and about $80,000 a day at the start of 2008. The market is very volatile[v], but at the time of writing (June 2008) this has risen to between $140,000[vi] and $200,000 a day[vii]. Capesize ships are used in particular for raw materials such as coal and iron ore.

Across the longer distance sectors, because short term bulk capacity is fixed, the ship charter market is very sensitive to fluctuations in demand.

There is thus variation in the proportion of shipping costs represented by fuel arising from the volatility in charter rates and the choice of port before any variation in oil price is taken into account.

However, the recent oil price rise has had a significant effect on the cost of shipping and this can be illustrated by reworking some published figures for a trip between South America and Northern Europe. The payload is 80,000 tonnes and in 2004/5 was taking about 24 days. There are some lesser scale weather effects which can effect fuel consumption, but these are not relevant in this comparative analysis. The analysis is shown in Table 1 below. The next table shows the effect of slowing down the ship by 5% (adding 1.2 days) to save fuel.

Table 1
Key elements of total cost

	Bunker fuel $300 tonne	Bunker fuel $650 tonne
Charter cost	$720,000	$720,000
Interest on cargo value	$168,000	$168,000
Fuel	$432,000	$936,000
Harbour fees	$53,000	$53,000
Total	***$1,373,000***	***$1,877,000***

Source: CE Delft 2005, Bunkerworld, MTRU calculations

Table 2
Viability of speed reduction to save fuel

	Bunker fuel $300 tonne, low speed	Bunker fuel $650 tonne, low speed
Charter cost	$756,000	$756,000
Interest on cargo value	$176,000	$176,000
Fuel	$393,000	$852,000
Harbour fees	$53,000	$53,000
Total	***$1,378,000***	***$1,837,000***
Difference from normal speed	**+ $5,000**	**-$40,000**

Source: CE Delft 2005, Bunkerworld, MTRU calculations

It can be seen from the above that one approach to the fuel consumption problem is to slow ships down, and if necessary add extra ships to maintain total capacity on a route. This has already been adopted by some long distance carriers[viii]. The same source reports that a reduction from 24 knots to 20.5 knots average speed would save $50m a year for a ship capable of carrying 8,500 twenty foot containers between China and Northern Europe. This is about 100,000 tonnes of bunker fuel, about 85,000 tonnes of carbon. This would, however, add two to three days to the journey.

Such long distance operators consider around 20 knots an optimum speed for fuel consumption in the present fleet and one which is at the limit of acceptability in terms of transit times. Slower speed, combined with shippers accepting profit reductions, has meant that rates have been held back to some extent. However, carbon emissions have already been reduced per tonne carried. This is of course countered by growth in international trade and it remains to be seen how far this will slow down, stabilise or reduce in terms of the distance that goods travel around the world.

However, such economies are not limited to long distance freight. Closer to the UK, an Irish Ferry operator has added 16 minutes to its fast ferry service between Wales and Eire, currently 99 minutes[ix]. Stena Line said,

“It's amazing how much we can save just by slowing the craft down."

Impact of the oil price rise: longer term

Overall this sensitivity to oil price means that international trade will become significantly more expensive in the longer term. In the past low labour costs and tariff reductions have created cheap imports and been accompanied by major relocation of manufacturing industries, and some agriculture, to places distant from their markets. If the oil price continues to rise, overall prices will rise but there is likely to be a switch from distant production to production nearer home.

The overall economic impact will be that cost increases will be limited by the differential in production costs. Thus it may be more expensive to produce some goods in Europe for European consumption than in the Far East, but less than the cost of cheap production plus expensive transport.

To illustrate this with a real world example, China has been expanding its steel exports to the US rapidly in the last decade. A recent analysis[x] showed that in December 2007, steel imports from China to the US were 30% higher than a year before. In December 2008 they were the same as the year before and are currently falling. Meanwhile US steel production has started growing. An analysis of shipping plus manufacturing costs shows that the additional shipping costs have now made US steel cheaper than the imported product.

In general terms, the higher the value of the product the less impact the increased transport cost will have on final price. The higher the cost differential (usually wages) between the consuming country and the producing country, the more likely it is that the current pattern will continue, although higher prices would normally mean less consumer demand.

Overall, the rise in oil price could have a similar short term effect to a carbon tax which reflects both transport and production costs, as briefly outlined in Phase One of this project. The balance between the strength of implementation of such a policy, and allowing the impact of oil price rises to change patterns of production and consumption on their own, depends on the price of oil. In a real sense, the excessive cheapness of transport has distorted markets and the removal of this needs time to work through. The preferred approach is to set up the carbon content policy while adjusting short term rates in the light of actual oil prices. This allows for adjustment in terms of product choice and changes in sources.

Maritime propulsion and bunker fuels

While the oil price rise may act like a carbon charge in the short term, there is another issue which needs to be considered in relation to international shipping. There are two key issues: short term improvements to fuels and short to long term improvements to ship and propulsion design.

Bunker crude or bio-crude?

The first is that existing maritime engines burn a particularly viscous and impure form of diesel. This has to be pre-heated to allow efficient working and free flow of fuel. The pollution occurs away from centres of population and is only now being seen as a major problem. The heavily used Baltic area ports have already taken steps to clean up bunker fuel by creating the SOx Emissions Control Area (SECA) which limits ships to using fuel with less than 1.5% SOx. The International Maritime Organisation has proposed this as a standard for all shipping by 2010.

One obvious option for ships which use bunker oil is to switch to unrefined plant oils. For use in normal diesels such as those in cars, a simple oil such as rape seed needs to be altered chemically to become bio-diesel. Given the nature of the maritime engines, such simpler bio-fuels can be used directly with minor modification. In the short term, the supply of bunker fuels could be switched to bio-crude – unrefined plant oils. At the end of last year, plant oils were about 25% more expensive than bunker crude[xi]. This balance is changing due to oil price rises and at the same time some companies are choosing low sulphur fuel on environmental grounds. This is more expensive than current bunker fuels and is not always available.

Given the current debate over how far bio-fuels have fed the rise in food prices, expanding its use could be counter productive. However, in policy terms the use of simpler biofuels in ships would achieve better CO2 replacement rates than biofuels in cars or trucks because it avoids the energy needed for refining. The EU should review its biofuel policy to prioritise bunker stocks for shipping and if necessary reduce its commitment for the bio-content in road transport fuel.

It should be noted that the current price of oil, and the need to reduce SOx in bunker fuel to meet new international standards, will make plant oil increasingly comparable in price to fossil fuel oils.

A final improvement would be to avoid fuel burning while ships are in port – new and specialist electric supply points are needed at quayside.

There are two other obvious areas where the efficiency of maritime transport can be improved: how efficiently the ship travels through the water and the efficiency of the method of propulsion.

Hydrodynamics

The first concerns the hydrodynamics of the hull and its interaction with the design and speed of the propeller. How smoothly the hull passes through the water depends on several factors, the simplest of which is keeping it clean. Coatings which reduce drag can be used and beyond this there are more radical redesigns including several hull elements. However, the flow of water, particularly around the propulsion area, has to be considered as an integral part of hull design.

There are already several designs for pentamarans[xii] including a zero emissions concept ship[xiii]. The basic approach is to reduce water resistance by creating a long slim central hull and to make it stable by using two sets of outriding “fins”. This can also remove the need for ballast, ensuring more cargo can be carried and reducing marine pollution. The concept ship, entitled E/S Orcelle, also proposes the use of wind, solar, and wave power, combined with fuel cell storage and electrically powered propeller pods[xiv].

Pentamarans can produce faster ships (around 40 knots) suitable for ferries or coastal shipping which can compete with road transport times. Of greater interest here is the large market for long distance cargo vessels which travel at slower speeds (15 to 20 knots).

Improved propulsion

As with land based transport, there is considerable scope for improving marine diesel performance, although the techniques are very different. Capturing waste heat for propulsion is an obvious means of improvement, but very few ship builders have done this so far because oil was so cheap that the capital cost was not worthwhile. Energy efficiency standards for ships are already a focus of research for the International Maritime Organisation (IMO) and could be phased in using existing technology in the short to medium term.

This should be linked to the longer term research into new propulsion methods, including wind assistance, conversion of wind and solar energy to electric power and hydrogen. Wind assistance, in the form of kite-like sails is already a reality on the MS Beluga SkySails, which runs between Germany and Venezuela[xv]. These can be retrofitted and are currently being evaluated. An average in use fuel saving of at least 10% should be possible even with the first generation design. In ideal conditions it can reduce consumption by 50% and monitoring the performance of MS Beluga will lead to improved second generation designs.

Commercial applications are high risk, and ship building has a high capital cost. It is proposed that part of the current transport capital budget should be reallocated to fund or support the building of prototype vessels in the UK, in collaboration with maritime centres for research and development. The DfT has already undertaken some desktop research work in this field[xvi].

Summary and implications for UK policy

From the above analysis, the operational changes to improve performance can be summarised in the following Table.

Table 3
Example operational changes and timescales

Short term (to 2012)	**Medium term (to 2020)**	**Long term (2020 on)**
Slower cruising speeds	Slower cruising speeds	Optimum design speeds
Improved hull maintenance	Improved hull maintenance	Improved hull maintenance
	Improved conventional engines	New types of propulsion (at lower power)
	New hull designs (smaller vessels)	New hull designs (all vessels)
Use of bio crude to replace bunker crude	Use of bio crude to replace bunker crude	
Wind assistance (1st generation)	Wind assistance (2nd generation)	Wind assistance (2nd generation)
		Advanced wind power
	Solar power	Solar power
		Wave power

In addition to using less and cleaner fuels, the price of oil is likely to reduce the viability of certain global trades, especially where trade is based on developing country production costs being low compared to consumer country production costs. In the very long term the implications of global development and equalisation are that many of these trades will relocate back to consumer countries in any case, since the differentials in production costs would be removed.

There are several elements to a marine policy framework which will bring about the improvements set out above.

Summary of marine policy framework

The carbon cost of sea transport should be included in any carbon tax on the sale of goods.

The easiest method of applying this would be a flat rate addition to port charges based on emissions per charter, preferably at EU level.

Any carbon harbour tax must take account of the fluctuations and current high price of oil and be phased in.

The EU should drop its support for refined biofuel in road vehicles and prioritise the replacement of bunker crude with bio crude as a short to medium term measure.

A review of port facilities to identify where new power supply infrastructure is needed should be undertaken.

Following this review a programme of port power supply improvement should be undertaken, based on local generation using renewable sources.

The Government should initiate a major research and development project on marine propulsion and hull design including wind assistance.

The marine project will need sufficient capital funding to build a sizeable demonstration vessel.

References

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xv For example see *Gone with the wind on 'kite ship',* BBC World News, 23rd January 2008 http://news.bbc.co.uk/1/hi/world/europe/7205217.stm

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