MARINE ENVIRONMENT PROTECTION COMMITTEE
60th session
Agenda item 4

MEPC 60/INF.7
18 December 2009
ENGLISH ONLY

PREVENTION OF AIR POLLUTION FROM SHIPS

Effects on sea transport cost due to an International Fund for GHG emission for ships

Submitted by Denmark

SUMMARY

Executive summary:	At annex a background note is attached demonstrating the possible effects on sea transport cost resulting from the introduction of an International Fund for GHG emissions from ships as proposed in MEPC 60/4/8
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.1 and 7.3.1.3
Action to be taken:	Paragraph 2
Related document:	MEPC 60/4/8

1 At the request of the Danish Maritime Authority the Department of Maritime Research and Innovation at the University of Southern Denmark has looked into the possible effects on sea transport cost resulting from the introduction of an International Fund for GHG emissions from ships as proposed in document MEPC 60/4/8.

Action requested of the Committee

2 The Committee is invited to note the information provided.

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ANNEX

DEPARTMENT OF MARITIME RESEARCH AND INNOVATION
INSTITUT FOR MARITIM FORSKNING OG INNOVATION

BACKGROUND NOTE ON:

EFFECTS ON SEA TRANSPORT COST DUE TO AN INTERNATIONAL FUND FOR GREENHOUSE GAS EMISSIONS FROM SHIPS

December 2009

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Table of contents

1.Introduction

This background note describes the potential effects on sea transport costs of GHG contributions introduced by the market-based proposal on an International Fund for Greenhouse Gas Emissions from Ships, cf. MEPC 60/4/8. The calculations have been performed by researchers at the Department of Maritime Research and Innovation at the University of Southern Denmark.

This background note focuses only on container transport but the presented methodology may just as well be used for other types of ships, e.g. bulk carriers, tankers, etc.

The note is divided into different sections starting out with an executive summary followed by a section focusing on global container shipping. Then the developed model for calculation of the increase in costs due to the introduction of GHG contributions is described, and finally the potential increase in goods' costs for a number of goods is calculated.

2.Executive summary

The introduction of the GHG contribution on maritime fuel for ships in international trade will potentially have no or a very limited impact on the price of commodities transported by sea. The freight rate by sea consists of a fixed cost and a variable cost. The GHG contributions will influence only part of the variable cost. This means e.g. that for a containership a GHG contribution of 45 USD/ton will potentially increase the freight rate by 5%.

The potential impact on the price of commodities of introducing a GHG contribution of 45 USD/ton for a number of commodities has in this background note been calculated to be less than 1%. Even for a commodity like jute from Bangladesh, where the freight rate share of the price is more than 37%, a 45 USD/ton GHG contribution will potentially increase the price by only 1.9%.

3.Global container shipping pattern

The following Table 1 shows the global container pattern for 2006 distributed on continents (6). In 2006, the world total was: 146 645 000 TEU.

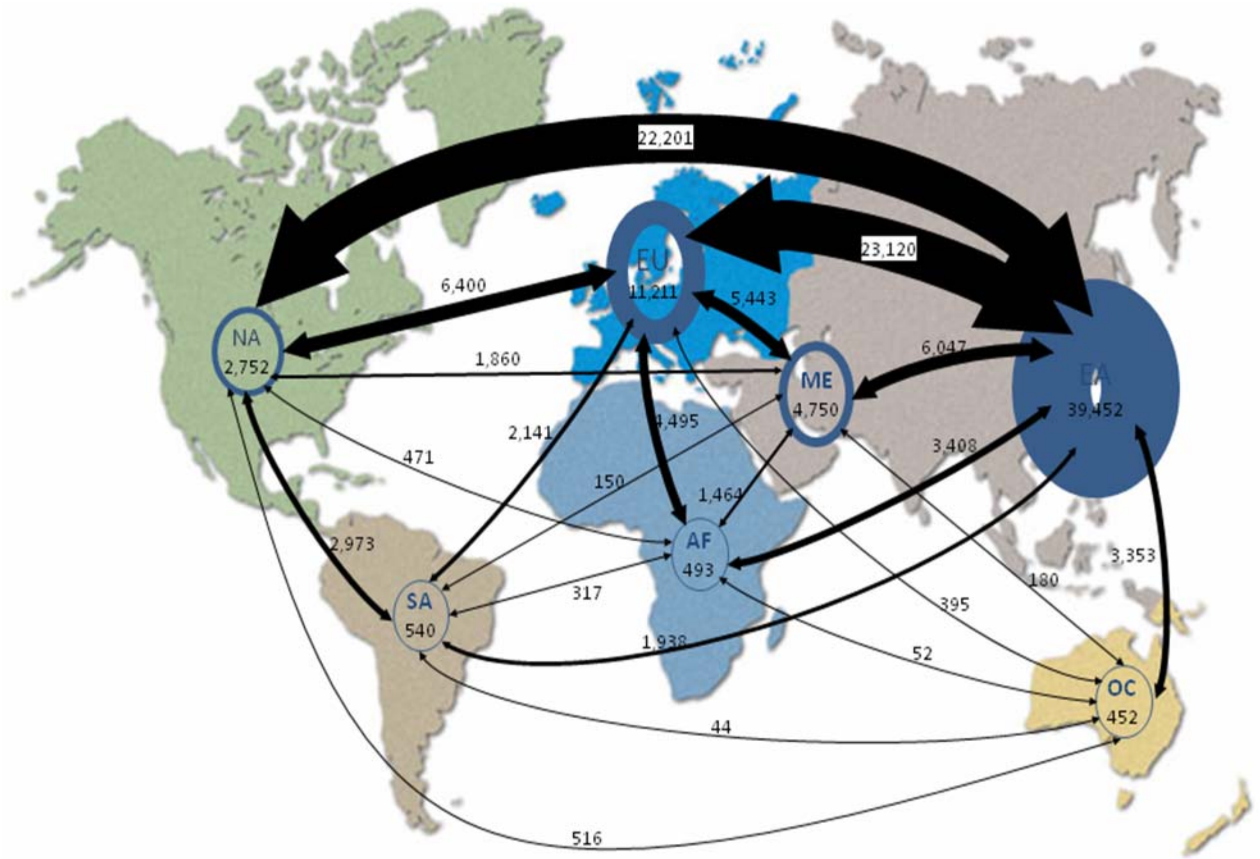
NA – North America
SA – South America
EA – East Asia
ME – Middle East
OC – Oceania
EU – Europe
AF – Africa

Table 1. Global container traffic between continents in 2006 ('000 TEUs) (6)

	NA	SA	EA	ME	OC	EU	AF
NA	2,752	2,973	22,201	1,860	516	6,400	471
	SA	540	1,938	150	44	4,141	317
		EA	39,542	6,074	3,353	23,120	3,408
			ME	4,750	180	5,443	1,646
				OC	452	395	52
					EU	11,211	4,495
World total :		146,645				AF	493

The global container traffic from Table 1 can also be seen in Figure 1.

Figure 1. Global Container traffic in 2006 ('000 TEUs) (own elaboration based on (6))



4.Modelling the influence of a GHG contribution

The basis is a model for estimating the total cost of one single voyage, which includes fixed cost and voyage cost (at sea and in port). The GHG contribution is then added to this model in order to calculate the changed rate of the transportation cost. Finally, different scenarios are tested in order to estimate the influence of the GHG contribution in different situations.

1.1 The model

For a given containership, the cost of a single voyage depends on the following factors (input):

d – voyage distance (nautical miles),

s – vessel speed (knots),

l – load factor,

p – fuel price (USD/ton).

Other variables needed in the model are:

TC – total cost (USD/voyage),

FC – fixed cost (USD/voyage),

VC^{sea} – voyage cost at sea (USD/voyage),

VC^{port} – voyage cost in port (USD/voyage),

CT – canal transit fee (USD/voyage),

t^{sea} – sailing days at sea (day),

t^{port} – port time (day),

fc – actual daily fixed cost of the vessel (USD/day),

f – actual daily main engine fuel consumption of the vessel (ton/day),

f^* – daily main engine fuel consumption at design speed (ton/day),

s^* – design speed (knot),

Z – vessel size (TEU),

c – average daily cost while vessel stays in port (USD/day).

The correlation between the variables is:

$$TC = FC + VC^{sea} + VC^{port} + CT \qquad (1)$$

$$FC = (t^{sea} + t^{port}) \times fc \qquad (2)$$

$$VC^{sea} = t^{sea} \times f \times p \qquad (3)$$

$$t^{sea} = d/s \qquad (4)$$

$$f = f^{*} \times (s/s^{*})^{3} \qquad (5)$$

$$t^{port} = 1 + (Z \times l \div 1.5 \times 2)/(30 \times 24) \qquad (6)$$

$$VC^{port} = t^{port} \times c \qquad 7)$$

Equation.1 shows that the total cost of a single voyage can be divided into fixed cost, voyage cost at sea, voyage cost in port and transit fee. Fixed cost depends on the number of sailing days (both at sea and in port) and the daily fixed cost as shown in Equation 2. Detailed data on daily fixed cost are found in recent research (1) analyzing the relationship between fixed cost and vessel size.

Equation 3 shows that voyage cost at sea is dependent on fuel price, daily fuel consumption and sailing time. Sailing time can be calculated by Equation 4 dividing sailing distance by vessel speed. Increased speed results in higher fuel consumption and the speed-dependent fuel consumption is given by Equation 5 (2) (3).

The time needed for loading and unloading containers in a port depends on the crane productivity and the number of cranes working simultaneously. In this model a crane productivity of 30 boxes per hour and 5 cranes working simultaneously is assumed. The number of boxes can be calculated by multiplying the vessel size with the load factor and then dividing by a TEU/box ratio of 1.5. As soon as the port time is known, the cost in port can be estimated by Equation 7, where the average daily port cost is from a recent research (1).
If the sailing route goes through a canal, the total cost also includes the canal transit fee, which normally depends on the gross registered ton. For each vessel size, the average gross registered ton is estimated based on the data in Clarkson's database (4), and then the charged toll can be given by an online canal toll calculator (5).

1.2 Calculation of cost change

Based on the model described in section 0, the sea transportation cost per unit can be calculated by Equation 8. If the GHG contribution is introduced, the fuel price will cause a higher sea transportation cost per unit, and the increase rate is given in Equation 10.

$$u = TC/(Z \times l) \qquad (8)$$

$$p' = p + Tax \qquad (9)$$

$$r = u'/u \qquad (10)$$

Where p' is the fuel price including the GHG contribution, u is the unit sea transportation cost and r is the change rate of the unit cost.

1.3 Analysis

Given a set of input variables, the above model can calculate the increased rate of the sea transportation unit cost caused by the GHG contribution. In this section, the relationship between the increase in rate and each input variable (elasticity) is analysed by fixing all other variables but one and then vary the value of that variable. First a basic case is assumed, and based on that an analysis for four vessel sizes (6000 TEU, 8000 TEU, 10000 TEU and 14000 TEU) has been made.

Basic case:

$$d = 6{,}000\ Nm$$

$$s = 22\ Knots$$

$$l = 0.7$$

$$p = 550\ USD/ton$$

$$CT = 0$$

$$fc = \begin{cases} 38{,}099\ USD/day & when\ vessel\ size\ is\ \ 6{,}000\ TEU \\ 46{,}775\ USD/day & when\ vessel\ size\ is\ \ 8{,}000\ TEU \\ 54{,}884\ USD/day & when\ vessel\ size\ is\ 10{,}000\ TEU \\ 69{,}916\ USD/day & when\ vessel\ size\ is\ 14{,}000\ TEU \end{cases}$$

$$f* = \begin{cases} 211\ ton/day & when\ vessel\ size\ is\ \ 6{,}000\ TEU \\ 238\ ton/day & when\ vessel\ size\ is\ \ 8{,}000\ TEU \\ 261\ ton/day & when\ vessel\ size\ is\ 10{,}000\ TEU \\ 283\ ton/day & when\ vessel\ size\ is\ 14{,}000\ TEU \end{cases}$$

The result of the analysis is shown in the following figures. In short, a GHG contribution of 45 USD will – with a fuel cost of 550 USD/ton – lead to an increase of the sea transportation unit cost of between 1% and 5%, and larger container vessels will have a slightly lower increase rate than smaller container vessels. Two of the input variables, voyage distance and load factor, have little effect on the increase rate caused by the GHG contribution (low elasticity), while the other two variables, vessel speed and fuel price, have a significantly positive effect on the unit cost increase rate (high elasticity).

Figure 2. The relationship between the increase rate and voyage distance

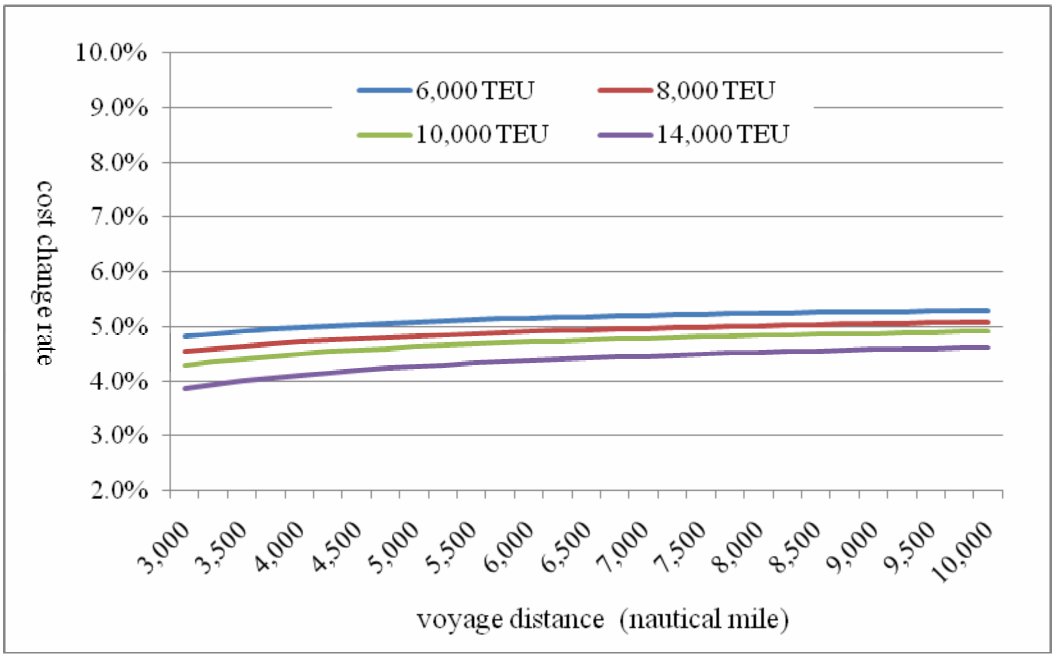


Figure 3. The relationship between the increase rate and vessel speed

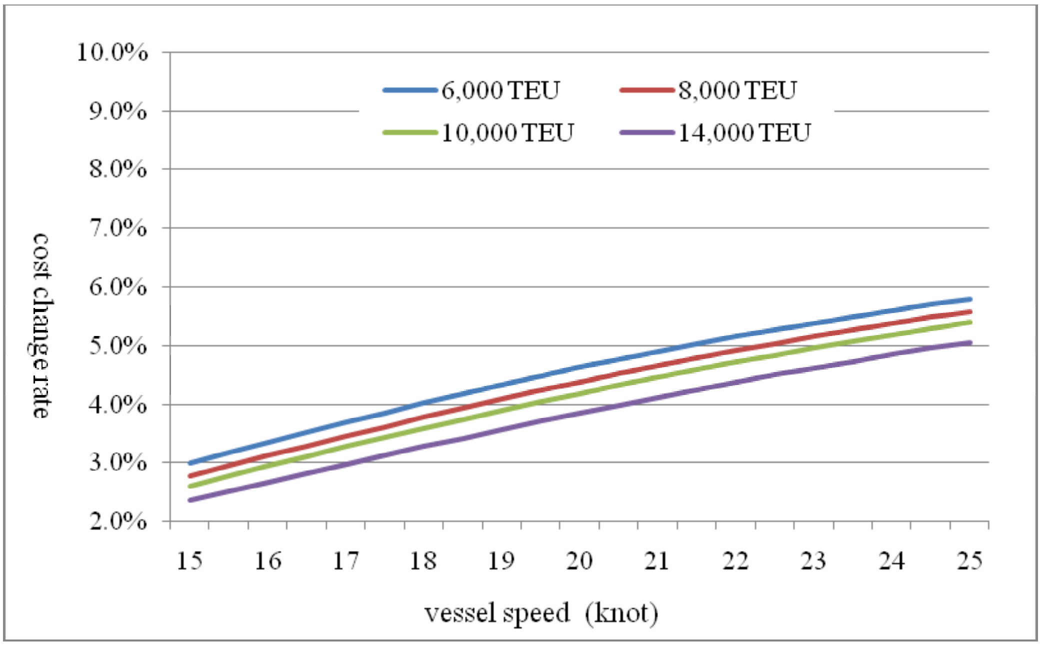


Figure 4. The relationship between the increase rate and load factor

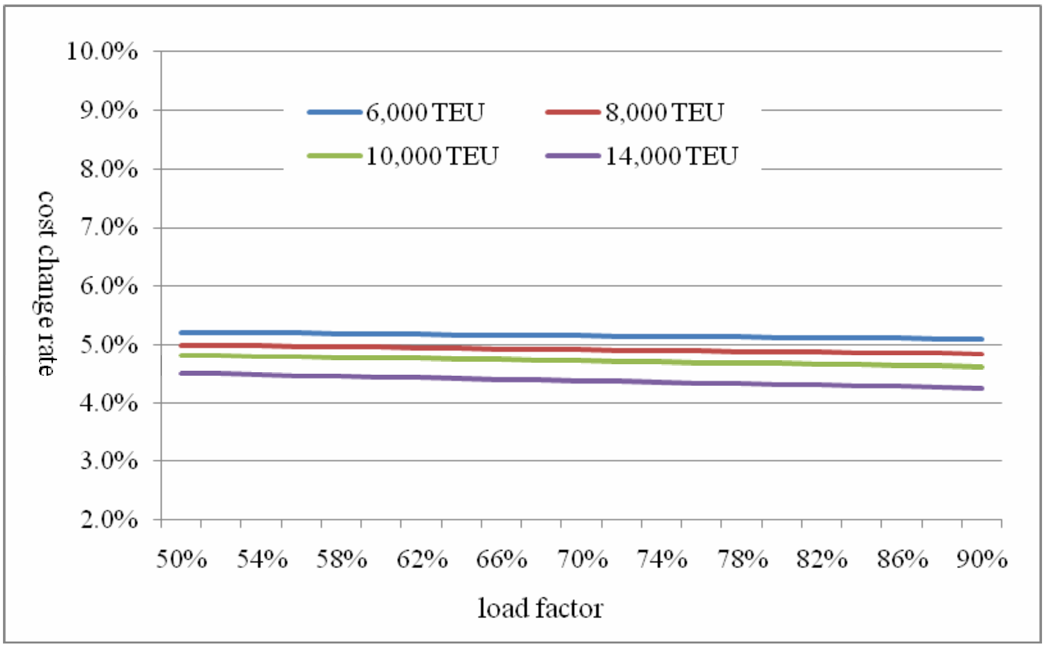


Figure 5. The relationship between the increase rate and fuel price

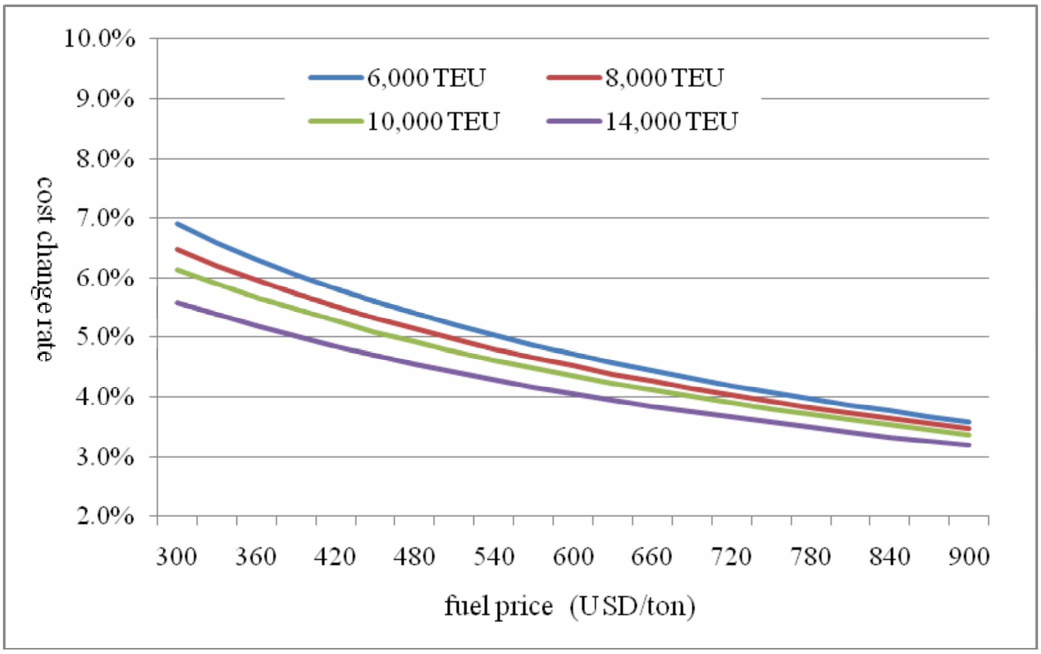
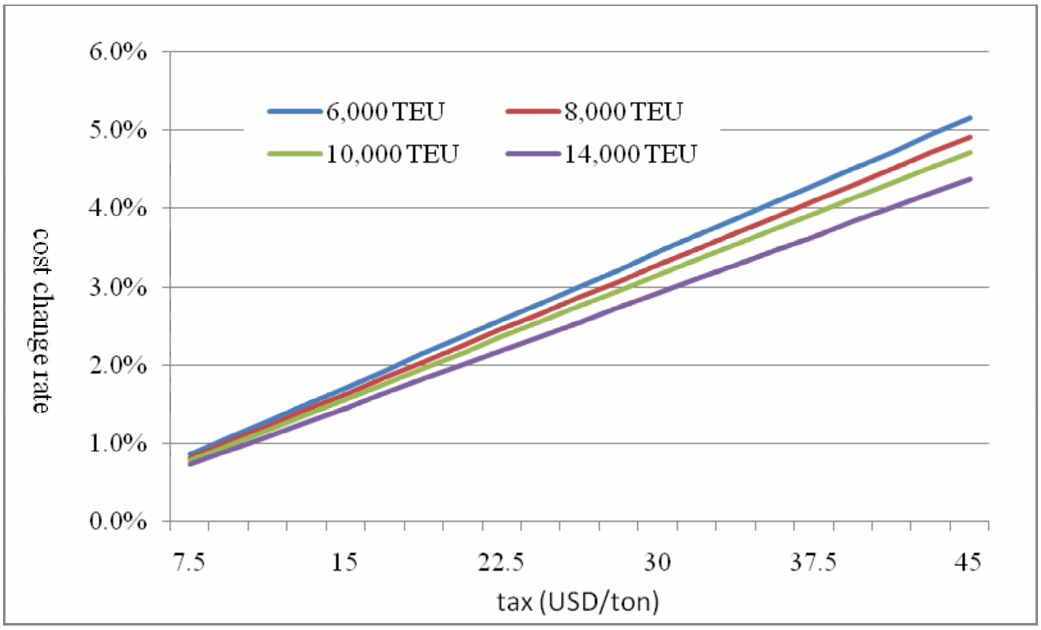


Figure 6. The relationship between the increase rate and GHG contribution (fuel price = 550 USD/ton)



This means that when discussing the impact on transport cost from a GHG contribution – besides for the size of the GHG contribution itself – focus has to be on the two parameters: Fuel price and vessel speed.

5. Potential increase in commodity price

Any increase in transport cost will to some extent influence the commodity price. In this case, a GHG contribution on maritime fuel for ships in international trade will have the biggest impact on commodities transported by sea and generally it can be expected that the longer the sea transport, the higher the impact on the price of the commodity.

However, the increase in transport costs (and thereby the freight rates) influences only the share of the commodity price that is directly related to transport. All other price elements (e.g. production, promotion, revenue, etc.) are not influenced by the GHG contribution.

The United Nations Conference on Trade and Development (UNCTAD) makes an annual Review of Maritime Transport (7). The UNCTAD report includes a calculation of the ratio of liner freight rates to prices of selected commodities. The percentages can be seen in Table 2.

Table 2. Ratio of liner freight rates to prices of selected commodities (7)

Ratio of liner freight rates to prices of selected commodities
(Percentages)

Commodity	Route	Freight rate as percentage of price [a]						
		1970	1980	1990	2004	2005	2006	2007
Rubber	Singapore/Malaysia–Europe	10.50	8.90	15.50	7.50	8.00	6.30	6.50
Jute	Bangladesh–Europe	12.10	19.80	21.20	27.60	30.50	37.20	44.20
Cocoa beans	Ghana–Europe	2.40	2.70	6.70	3.70	4.00	3.90	3.50
Coconut oil	Sri Lanka–Europe	8.90	12.60	n.a.	10.10	12.70	14.50	12.02
Tea	Sri Lanka–Europe	9.50	9.90	10.00	8.60	9.20	9.30	13.36
Coffee	Brazil–Europe	5.20	6.00	10.00	6.50	5.70	5.10	..
Coffee	Colombia (Atlantic)–Europe	4.20	3.30	6.80	2.30	3.10	3.00	2.50
Coffee	Colombia (Pacific)–Europe	4.50	4.40	7.40	2.60	4.10	3.70	3.60

Sources: UNCTAD secretariat on the basis of data supplied by the Royal Netherlands Shipowners' Association (data for 1970–1989) and conferences engaged in the respective trades (data for 1990–2006).

Note: Two dots (..) means that no rate was reported.

[a] Coffee (Brazil–Europe and Colombia–Europe) and coconut oil prices are based on c.i.f. (cost, insurance and freight). For cocoa beans (Ghana–Europe), the average daily prices in London are used. For tea, the Kenya auction prices are used. For the remaining commodities, prices are based on f.o.b. terms. The freight rates include, where applicable, bunker surcharges and currency adjustment factors, and a tank cleaning surcharge (for coconut oil only). Conversion of rates to other currencies is based on parities given in the Commodity Price Bulletin, published by UNCTAD. Annual freight rates were calculated by taking a weighted average of various freight quotes during the year, weighted by their period of duration. For the period 1990–2006, the prices of the commodities were taken from UNCTAD's Commodity Price Bulletin (see UNCTAD website).

This means that if a GHG contribution on bunker fuel is set at e.g. 45 USD/ton, the transport costs will increase by 5%, and if this increase is put directly on the freight rate, then the price of the commodity will increase by 5% multiplied by the freight rate as a percentage of the price.

For a commodity like e.g. rubber from Singapore/Malaysia to Europe, the potential price increase will then be 5% x 6.5% = 0.33%.

The potential price increase for the commodities shown in Table 2 can be seen in Table 3.

Table 3. Potential price increase for different commodities due to a 45 USD/ton GHG contribution on bunker fuel

Commodity	Route	Freight rate as % of price (2006)	Transport cost increase due to a GHG contribution of 45 USD/ton	Potential price increase due to a GHG contribution
Rubber	Singapore/Malaysia – Europe	6.30	5%	0.32%
Jute	Bangladesh – Europe	37.20	5%	1.86%
Cocoa beans	Ghana – Europe	3.90	5%	0.20%
Coconut oil	Sri Lanka – Europe	14.50	5%	0.73%
Tea	Sri Lanka – Europe	9.30	5%	0.47%
Coffee	Brazil – Europe	5.10	5%	0.26%
Coffee	Columbia (Atlantic) – Europe	3.00	5%	0.15%
Coffee	Columbia (Pacific) – Europe	3.70	5%	0.19%

This means that even for a commodity like jute from Bangladesh, where the freight rate accounts for more than 37% of the price, a GHG contribution on bunker fuel of 45 USD/ton will potentially increase the price by 1.9%.

For competing commodities the GHG contribution can, however, to some extent shift the competitive situation. If one provider of a commodity has a shorter transport route by sea to the market than another provider, a GHG contribution will weigh in favour of the provider with the shortest sea access to the common market. This can also be illustrated using the numbers in Table 3. Both Brazil and Columbia provide the European market with coffee that is, in this particular case, considered substitutable. The 45 USD/ton GHG contribution will then potentially increase the European price of Brazilian coffee by 0.26% and of Columbian (Atlantic) coffee by 0.15%. The resulting price distortion in favour of the Columbian coffee will in this case be almost negligible.

6. References

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[4]. Clarkson Shipping Intelligence Network, www.clarksons.net, viewed 23 Oct. 09.

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[6]. Yoshinori NITA, Yasuhiro AKAKURA, Tomihiro WATANABE, Analysis on World Container Ship Movement and Containerized Cargo Flow (2008) – Analysis on Containerization in Transpacific Trade – Technical Note of NILIM, No. 467, June 2008 (YSK-N-159), P22,23.

[7]. UNCTAD secretariat, Review of Maritime Transport 2008, United Nations Publication, ISBN 978-92-1-112758-4, ISSN 0566-7682, P88.

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