The effectiveness of a European speed limit versus an international bunker-levy to reduce CO_2 emissions from container shipping

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Tuesday 9 April 2013

STARTING POINT

Shipping and EU Policy Adviser John Maggs "A mandatory speed limit found for different ship types…can create a benefit to society **without** costing owners" (Lloyd's List, 2011).

A reaction to IMO proposal for a bunker levy (tax) to limit CO2 emissions.

OBJECTIVE: To challenge this view taking the case of liner shipping services for which a need of weekly services is required.

Why liner shipping = first emitter of CO2

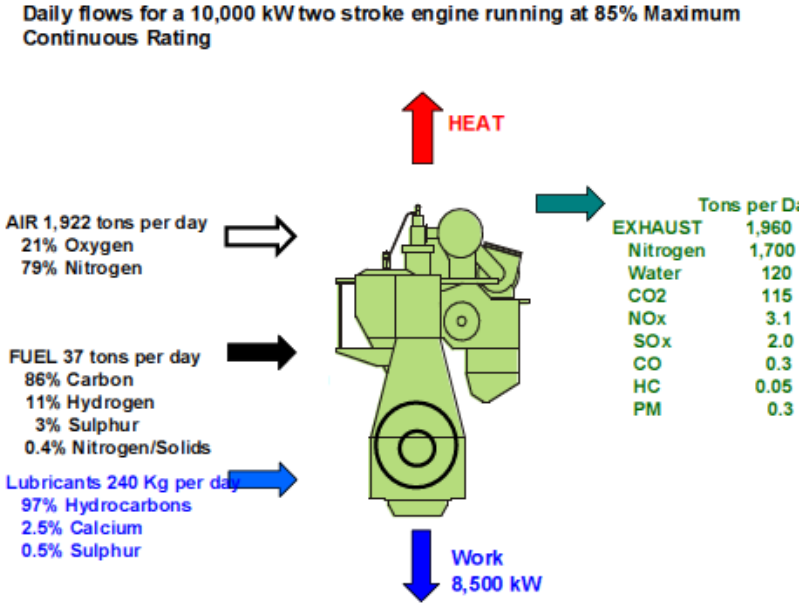
EUROMED MANAGEMENT

AGENDA

1. Research question
2. Model
3. Application
4. Conclusions

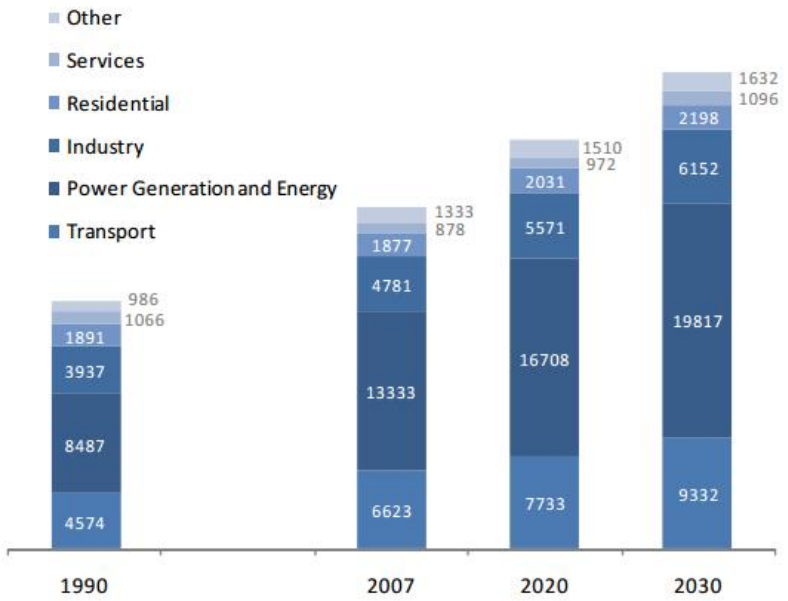
1. RESEARCH QUESTION

Due to fuel combustion, shipping generates emissions.



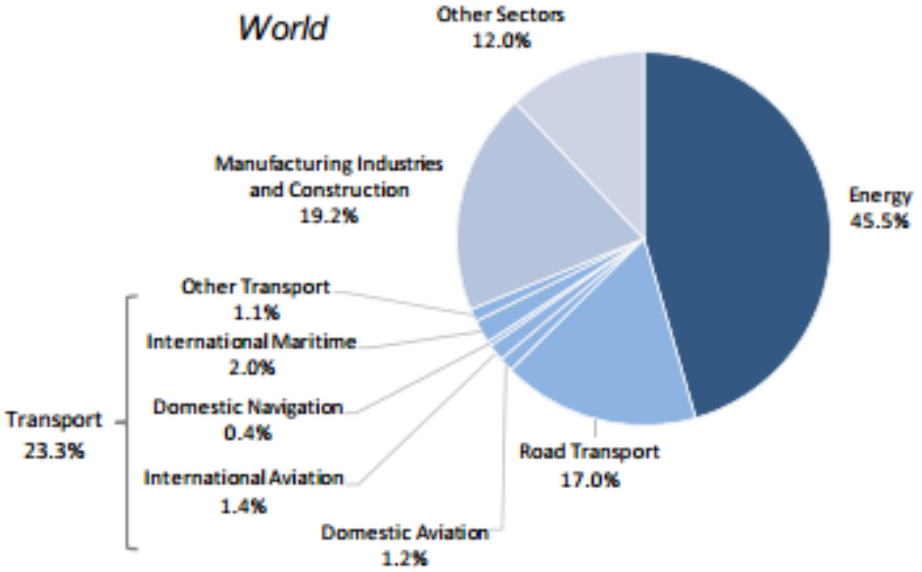
	Local	Regional	Global	Main impacts
Particulates Matters (PM)	■			Cardiopulmonary
Sulfur dioxide (Sox)	■	■		Cardiopulmonary Acid Rain
Oxides of nitrogen (Nox)	■	■	■	Cardiopulmonary Acid Rain
Carbon dioxide (CO2)			■	Global warming

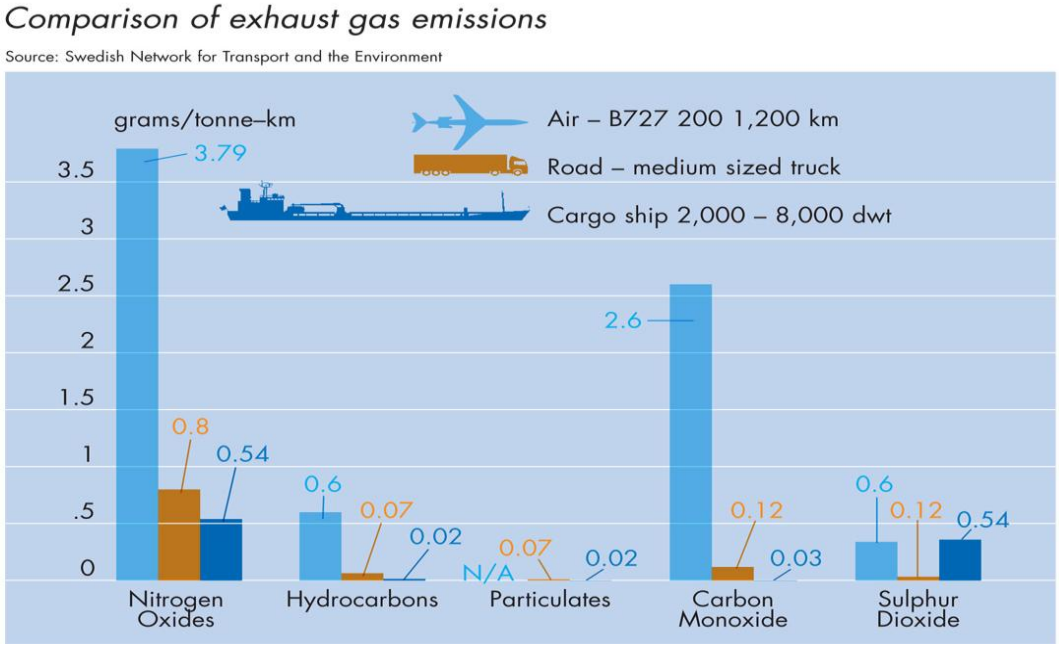
Figure 1-2: Projected world energy-related CO2 emissions (Mt)



Source: (IEA, 2009)

1.5B: 2005 Global CO2 Emissions from Fuel Combustion





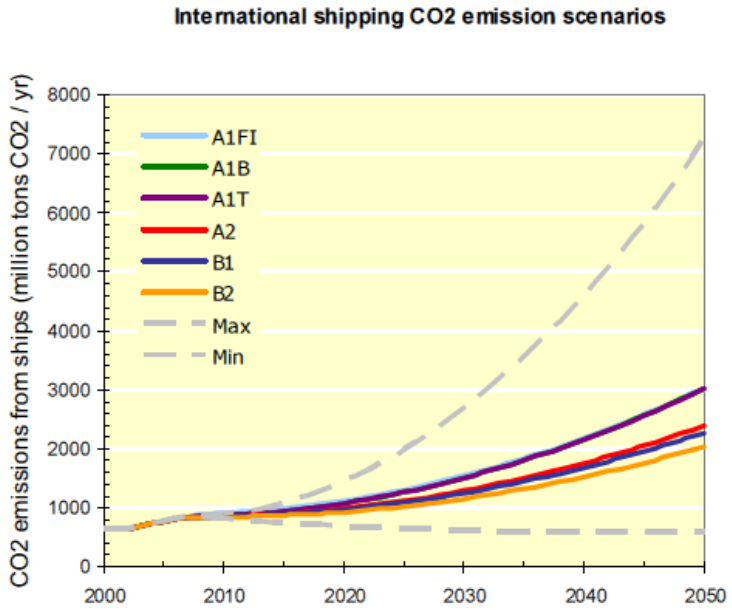
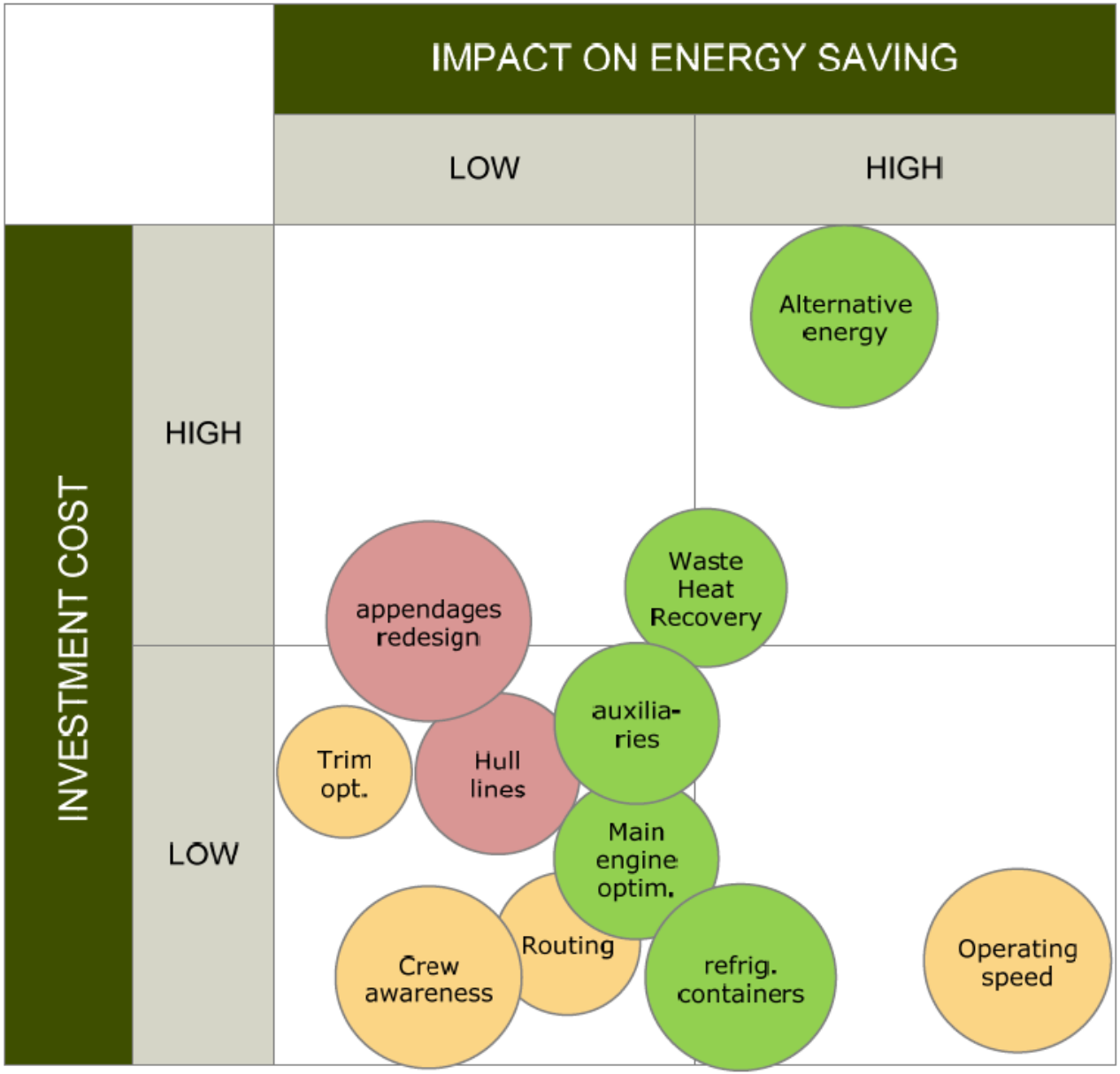


Figure 7-1: CO_2 emissions scenarios for international shipping (Second IMO GHG Study 2009)


IMPACT ON ENERGY SAVING
LOW
HIGH
INVESTMENT COST
HIGH
LOW
Alternative energy
Waste Heat Recovery
appendages redesign
auxilia-ries
Trim opt.
Hull lines
Main engine optim.
Routing
Crew awareness
refrig. containers
Operating speed

To play on operating speed is one the most efficient ways to reduce CO2 emissions. It can be regulated:

1. Directly in setting a speed limit by EU
2. Indirectly in setting a tax on bunker (fuel price) by IMO

Objective: Show through a model/application that these two mechanisms are not equivalent and what could be their implications on shipping lines behaviour wrt fleet mix.

1. MODEL

The two policies (speed limit versus tax) affect liner shipping profit functions in different ways.

$$\Pi = \rho_d - CB_d^M - CB_d^A - CV_d - CD_d$$

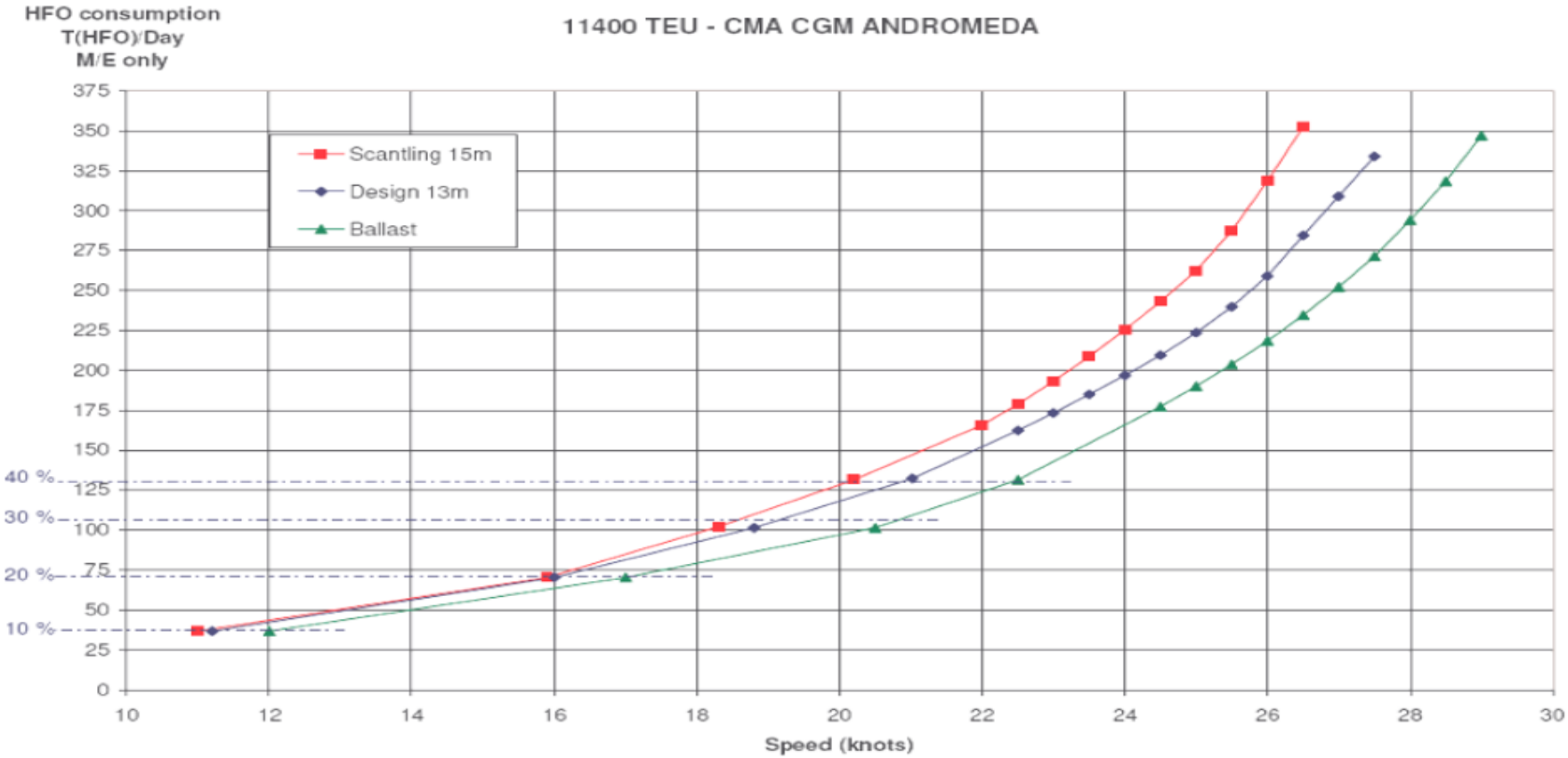
Π	the average daily profit of all vessels operating on the cycle
p_d	the average daily revenue
CB^M_d	the average daily bunker cost for the main engine
CB^A_d	the average daily bunker cost for the auxiliary engine
CV_d	the average daily fixed cost
CD_d	the average daily depreciation cost of the containers

A tax plays on $C_b^{M,Tx} = C_b^M + Tx$ and $C_b^{A,Tx} = C_b^A + Tx$.

$$\begin{aligned}\Pi &= \rho_d - CB_d^M - CB_d^A - CV_d - CD_d \\ &= \frac{1}{7}\sum_{j\in\Delta}(\rho^{jAB}q^{jAB} + \rho^{jBA}q^{jBA}) - C_b^M\left(\frac{SF^M + S^R F^{MR}}{168}\right) - C_b^A N F_F^A - C_b^A N\frac{(q^{ZAB}+q^{ZBA})F^Z + (q^{FAB}+q^{FBA})F^{FZ}}{2} - C_v N \\ &\quad - N\left[\frac{dp^d(q^{dAB}+q^{dBA})}{2} + dp^R \max(q^{RAB};q^{RBA})\right] \end{aligned} \tag{20}$$

A speed limit plays on S as S^R+

$$F^M = (SFOC^M EL^M PS^M)\left(\frac{V_i}{V^{DS}}\right)^a \frac{24}{10^6}$$



Typical fuel consumption curve for 11400Teu vessel, CMA CGM

Source: Copil (2011, Mai)

Total CO2 emissions – Main engine

$$ECO2_d^M = ECO2_d^{M-AB} = ECO2_d^{M-BA} = 3.17\frac{SF^M + S^R F^{MR}}{168}$$

Total CO2 emissions – Auxiliary engine

$$ECO2_d^A = 3.17\left(F_F^A + \frac{(q^{ZAB} + q^{ZBA})F^Z + (q^{FAB} + q^{FBA})F^F}{2}\right)N$$

3. APPLICATION

Table 1
Services characteristics in September 2010.

	Hamburg Süd Safran Europe/South America	MSC/CMA CGM Victory Europe/North America
Number of vessels[a]	7	7
Vessel capacity (TEU)[a]	5905	6470
Main engine power (kW)[b]	41,186	56,273
Auxiliary engine power (kW)[c]	2433	2433
Design speed (knots)[b]	23.3	24.7
Reefer capacity (TEU)[b]	1 365	412
Vessel age (year)[b]	2.5	7.4
Cycle distance (nautical miles)[d]	11, 810	7600
Speed at sea (knots)[e]	15.08	15.07
Intercontinental time at sea per cycle (days)[a]	30	21
Cycle time (days)[a]	49	49
Weekly demand (dry) (TEU)[a]	3774	3572
Weekly demand (dry) (TEU)[a]	3, 585	3516
Weekly demand (frozen/fresh) (TEU) [a,e]	797/398	412

[a] From Hamburg Süd and CMA-CGM website schedule and Drewry Research (2010).
[b] From Lloyd's Register Fairplay Database (2010).
[c] From Buhaug et al. (2009).
[d] From Sea Distance (2011) for successively a Rotterdam/Santos and Charleston/Bremerhaven return trip.
[e] Estimated from data.

Table 2
Total profit in $ and amount of CO_2 emitted as a function of the number of vessels.

N	Northern Europe/South America			Northern Europe/North America		
	V_i in knots	CO_2 in tons	Profit in $	V_i in knots	CO_2 in tons	Profit in $
6	19.67	1699	678,561	22.62	1635	1,392,418
7	**15.08**	**1360**	**697,112**	**15.07**	**1072**	**1,451,041**
8	12.23	1236	681,692	11.30	901	1,447,942
9	10.28	1202	652,063	9.04	842	1,426,990
10	8.87	1213	615,457	7.53	828	1,399,012

Table 3
Total profit in $ with a bunker-levy policy.

Assumption: Tax=3.17x 15 Euro/ton CO2 and 3.17x 30 Euro/ton (Metcalf, 2007)

N	Northern Europe/South America		Northern Europe/North America	
	Bunker-levy at 47.5 $/ton	Bunker-levy at 95.1 $/ton	Bunker-levy at 47.5 $/ton	Bunker-levy at 95.1 $/ton
6	653,073	627,586	1,367,895	1,343,372
7	**676,714**	**656,315**	**1,434,960**	1,418,880
8	663,152	644,612	1,434,434	**1,420,926**
9	634,030	615,997	1,414,357	1,401,724
10	597,267	579,078	1,386,586	1,374,159

A tax does not change the optimal configuration (7 vessels deployed and same amount of CO2 emissions) on Northern Europe/South America trade but reduces profit (polluter pays for the externality).

The only case when it changes is on Transatlantic at high level of tax.

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Table 4
Total profit in $ and amount of CO_2 emitted with a speed limit policy. *Assumption: set at 200 nm @ 15 kt*

N	Northern Europe/South America			Northern Europe/North America		
	V_i in knots	CO_2 in tons	Profit in $	V_i in knots	CO_2 in tons	Profit in $
6	20.66	1815	660,262	24.55	1840	1,360,067
7	**15.66**	**1417**	**688,059**	15.91	1139	1,440,452
8	12.60	1271	676,111	**11.77**	**936**	**1,442,417**
9	10.55	1228	648,069	9.34	866	1,423,228
10	9.07	1233	612,289	7.74	847	1,396,018

1. On Northern Europe/South America trade, a speed limit does not change the optimal configuration, increases the amount of CO2 emitted (from 1360 to 1417) and reduces the ship-owner profit (from 697 112 USD to 688 059 USD)

2. On Northern Europe/North America trade, a speed limit changes the optimal configuration (from 7 to 8 vessels), reduces the owner profit (from 1 451 041 USD to 1 442 417 USD) and the amount of CO2 emitted (from 1072 to 936). The price of one ton of CO2 saved is then = 63.4 USD/ton CO2 > What society is willing to pay!!!!!

4. CONCLUSIONS

1. A tax can be efficient only at high level of taxation and on market with specific characteristics.

2. A speed limit might be counter-productive at a global scale (more emissions than initally).

3. A speed limit in European waters will increase transportation costs for Short sea shipping and reduces transfer of trade from road to sea (high share of incompressible time).

4. Confirm that if for SOX, NOX… a regional policy might make sense but not for CO2 for which the global impact should be looked at = Call for an international agreement (IMO rather than EU) if we want to imply a change in ship-owners behaviour.

Q&A

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