Applying systems thinking approach for qualitative analysis of GHG emissions regulations in shipping

Abstract

A number of regulatory options have been discussed for the reduction of GHG's in the maritime sector. The International Maritime Organisation has on the table a mixture of measures ranging from command and control instruments such as the Energy Efficiency Design Index to market based measures such as international cap-and-trade and levy. It is possible that policies in this area will develop to be a mixture of the above international measures as well as regional measures. In light of this, the paper attempts to contextualize the potential of reduction of GHG emissions using a holistic/systemic approach. An in-depth characterisation and analysis of the current/existing shipping stakeholder space is made in order to identify potential responsible entities for the proposed measures. Barriers and opportunities existing therein are further analysed with particular focus on the principal agent problem. The Viable Systems Model is used to depict system roles of the shipowner and charterer and ties together the relevant findings from the preceding systems tools.

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1. Background to the shipping industry

The shipping industry provides transport for the movement of cargoes that are traded regionally and internationally and as such the industry is a global network of stakeholders that exist to pursue this purpose. International shipping accounted for 2% to 4% of global CO_2 emissions in 2009 and it is estimated that this share will grow by 150 -250% (compared to emissions in 2007) by 2050, if the industry is left uncontrolled and in absence of policies. To this date, International shipping and aviation have not been incorporated in a global treaty and have been categorically left out by United Nations Framework Convention on Climate Change (UNFCCC) in the Kyoto Protocol (1997) due to the inability to attribute bunker fuels/emissions to national inventories. However, the Protocol mandates the International Maritime Organisation (IMO) to address the issue of mitigation of maritime GHG's. Inter-governmental negotiations are underway in this regard, within the framework of the IMO's Marine Environment Protection Committee (MEPC).

The IMO is a specialised UN agency responsible for regulating the maritime sector, which pursues its global mandate by adopting internationally agreed rules and standards that are implemented and enforced by state parties in the exercise of flag, port and coastal state jurisdictions. To do this without distorting maritime sector/contravention of UN Convention on Law of the Sea (UNCLOS), it applies a universal principle of 'No more favourable treatment' (NMFT). This is in contrast with UNFCCC, which applies a 'Common but Differentiated Responsibility' (CBDR) principle to the member states which constitute of annex i and non-annex i countries. This has led the non-annex i parties of the UN, to come to the IMO MEPC ascribing to the CBDR principle to divert from them, any universally applied GHG measures. A ship is a territorial extension of the country whose flag it flies and must be registered to a certain flag (i.e. country) in order to operate and be governed by the rules of that state. However, because the ship is a moveable entity, it becomes easy to change legal jurisdiction, by registering to a flag of choice (often called flag of convenience, that provide benefits such as tax and low compliance to safety, and lack of enforcement) resulting in lower costs of operation (as shown below in figure 1). For these reasons attribution of bunker fuels and CO_2 emissions to a specific nation is very complex (SBSTA, 1999; CSC & WWF, 2011). Shipping is understood to be placed in a perfectly competitive market structure (Stopford, 2009), where freight rates just breakeven with operational costs, thus cost cutting as highlighted above provides shipping the ability to survive and make profits during peaks. This investment nature gives little importance to CO2 emissions, which generally take a low priority amongst many other factors in shipping e.g. when setting a charterparty (CE Delft et al., 2009).

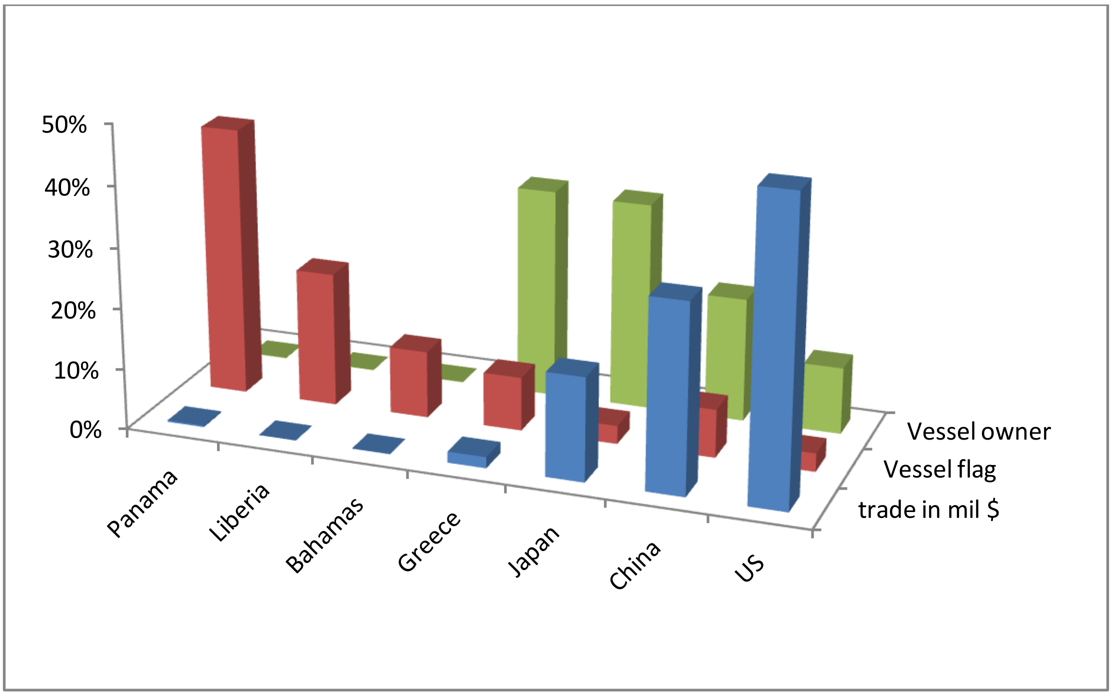

Figure 1: Comparison of vessel ownership, flag registration and trade.

Source: Compiled from UN Comtrade and Clarksons World Fleet monitor 2010

2. Brief outline of policy measures proposed for CO2 reduction in shipping

In general, for policy makers, there are three strands of measures that can be opted. The taxonomy of such measures is outlined below:

- Command and control measures – these are direct form of regulations that have high dependability and predictability but commonly prove inefficient and inflexible.
- Economic/Market based measures – tend be indirect form of regulation that tend to be efficient but not dependable.
- Information strategies/self regulation – tend be non-coercive, un-intrusive and cost effective but have low reliability and dependability.

Adapted from: (Gunningham et al., 1998)

In the light of the policies at the IMO, the diagram below shows how shipping policies are abundant in the command and control regime, in comparison to market and information based measures. This highlights that shipping over the decades has been accustomed to direct regulation, hence mitigating CO2 emission for shipping with other methods poses a significant challenge.

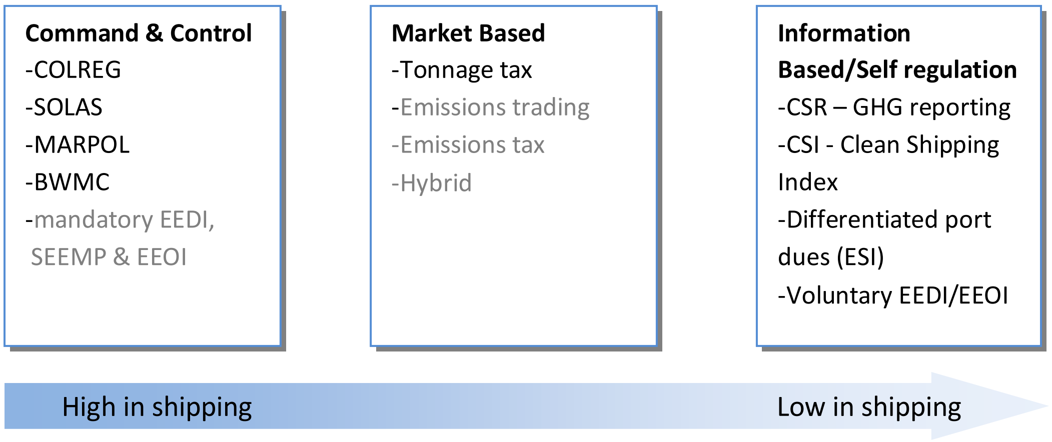

Figure 2: Use of different type of measures in shipping

Currently there are ten measures under consideration by the IMO for reducing GHG emissions from shipping. These have been proposed by various member states and international bodies, who have taken either a command and control (C&C) approach or market based (mbm) approach to meet the required level of reductions. Under C&C approach, proposals made by Bahamas, Japan in its Leveraged Incentive Scheme and World Shipping Council in its Vessel Effciciency Scheme, make use of the Energy Efficiency Design Index, which is applied to new ships, hence reliant on in-sector reductions. Under the mbm approach an international fund by Denmark, Port State Levy by Jamaica, Global Emissions Trading Scheme by Norway and Global sectoral emissions trading scheme by UK and France, with the exception of Ship Efficiency & Credit Trading by US, all rely on out of sector mechanism to achieve reductions i.e. carbon offsetting. It is beyond the scope of this paper to analyse the policy measures but IMO through its expert group study (IMO, 2010) and in the latest IMO GHG intersessional WG will be exploring these options in greater detail.

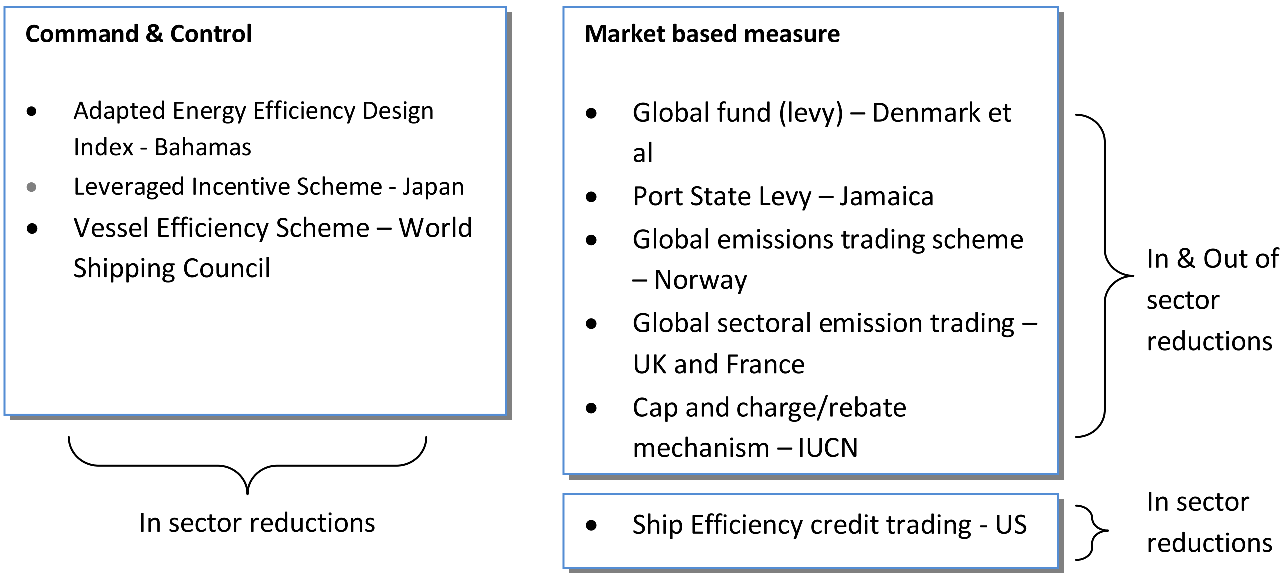

Figure 3: Overview of IMO policy measures

3. Stakeholder mapping and analysis

The future GHG regulation landscape for shipping is highly uncertain due to the plethora of proposals currently under consideration coupled with the complex regulatory structure within IMO and UNFCCC. At this juncture, a naive but important question arises as to why would an industry be subject to such mandatory regulations for energy efficiency when there has always been a business case for energy efficiency? For shipping, greater efficiency and reducing fuel consumption is a win-win situation: less air pollution from emissions and lower fuel bills (Sustainable Shipping, 2010), especially at current fuel prices of around $650 per tonne. This hints that there are intricate inadequacies within, which may be hampering the uptake of potential energy efficiency measures. This does not apply only to technical measures but operational as well, e.g. the Virtual Arrival code developed by OCIMF and Intertanko (Ranheim & Hallet, 2010), which made use of speed reduction based on known delays at ports, hence bringing together various stakeholders for a shared benefit. Initial trials show reduction of CO2 emissions by up to 27%, acclaimed also by (DNV, 2009). This is a great tool for the industry, as it removes some of the inefficiencies within that trade (oil traded on spot market), however there is still a need for it to be more standardised, to be applicable to tankers trading in different markets, as well as appealing to other ship types.

The analysis of barriers is important because MBM's need to provide incentive to change. One of the nine criteria (IMO, 2010) for MBM is that "the proposed MBM's potential to provide incentives to technological change and innovation – and the accommodation of current emission reduction and energy efficiency technologies". Hence, an understanding of incentivisation of stakeholders is important in order to understand why significant cost-effective energy efficiency measures are not being applied. A detailed understanding of the key stakeholders and barriers/opportunities within shipping is required, and to that end the generic stakeholder map below shows a bird's eye view of the participants within the sector. As a systems thinking tool, stakeholder map forms the initial stages, followed by other processes that form the nine step process in stakeholder analysis (Tansley, 2005). Using the power vs. stake of each stakeholder (two dimensional grid) will help to elicit which stakeholders have the most authority, influence in decision making and incentives to energy efficiency, which altogether will allow a policy to be targeted or geared towards these stakeholders. There are three main relationships/links (Ship owner and ship yard, Ship owner and charterer, Ship and port) that are being explored for further investigation of barriers/opportunities that exist therein. An outline of the main barriers (identified from literature) existing between these is provided in figure 4.

<u>Ship owner and ship yard</u>

According to Stopford (2009), basic ship designs varied little over the second half of the 20th century leading to the industry being classed as conservative. House of Commons (2009), linked the industry to low levels of R&D. In the initial design stage, "Shipyards react more on the principle that something is difficult to make, instead of expensive to make. Shipyards put up barriers that they only want to build vessels to type" AEA (2008). "In the preliminary design phase, some of the main contours, for the ship have already been set by the shipowner 'tender', thus innovative ideas may therefore be cut short" Veenstra & Ludema (2006). The influence of ship brokers in governing the design of a new ship is significant and they also discourage owners to change standard designs by arguing that these changes might negatively influence the resale value of the ship in the future" Veenstra & Ludema (2006). "Unlike some industries, shipping has a highly liquid sale and purchase market for its fixed assets, the ships, that fluctuates constantly on pure supply and demand factors" Lloyds List (2011), thus the inclusion (or non inclusion) of energy efficiency improvements are not reflected in the asset price, Stopford (2009). Moreover this market based approach to valuing ships leaves out the revenue/earning potential of ships which can take into account fuel efficiency measures, new design premiums and depreciation. This method of valuing ships is rarely taken into account but such methods are just making their way in to the books e.g. Value in Use, Lloyds List (2011).

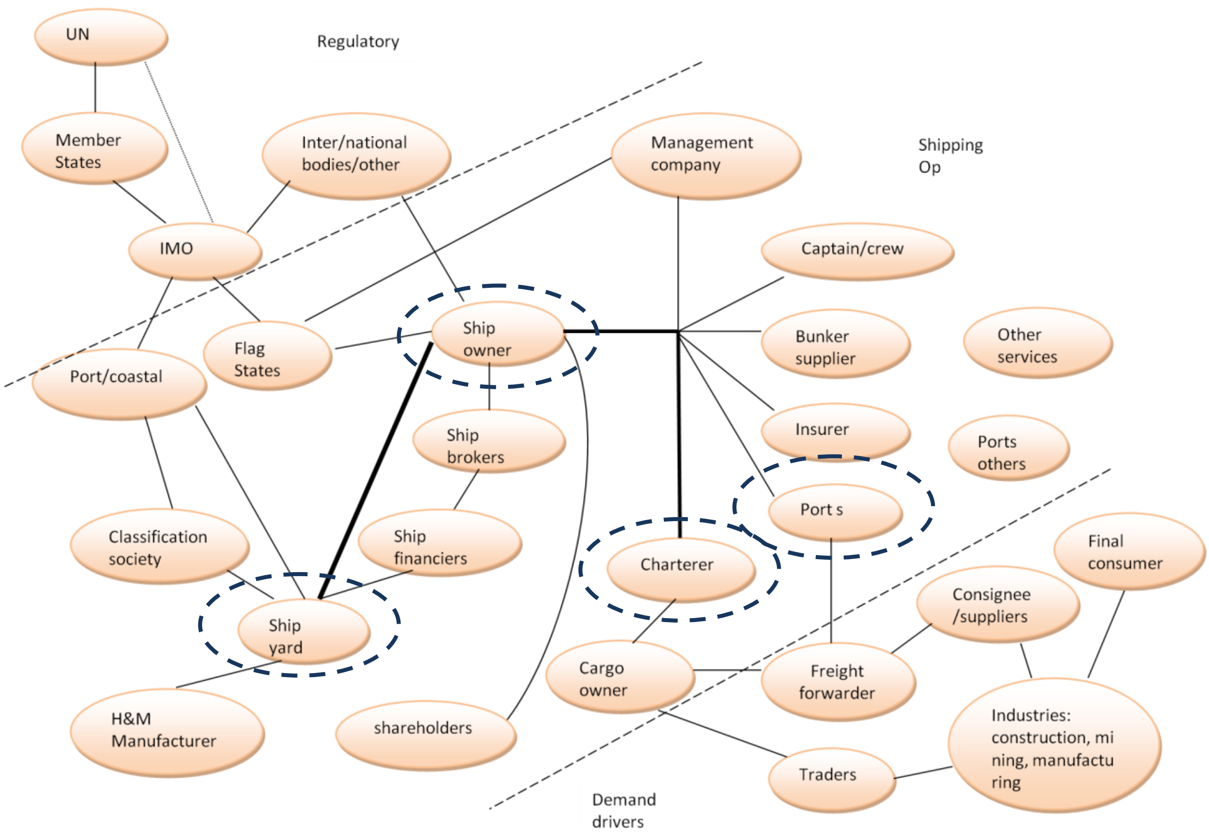

Figure 4: Stakeholder map of the shipping industry

<u>Ship owner and charterer</u>

The principal agent barrier is well documented in literature (AEA, 2008; CE Delft et al, 2009), whereby the ship owner has no incentive to improve the energy efficiency of a ship if the charterer is paying the fuel bills. According to AEA, 2008 traditionally the industry has been focused on fast delivery, especially in the general cargo and container sectors, as time spent in transit increases the inventory costs of the customer and speed reduction is limited to a small number of countries. Moreover, conditions set out in charter parties prevent slow steaming (BIMCO, 2008).

Ship and port

Standard charter party contracts stipulate that a chartered vessel must sail at 'utmost despatch' without consideration of berth availability at destination ports (Alvarez et al, 2010). This provides the master an incentive to sail at full speed to the ports which admit vessels on a first come first serve basis. According to DNV (2009) these berthing policies (and charter contracts) have the potential of removing around 60 million tonnes of CO_2 p.a. at a net benefit (cost savings) of \$80/tCO_2. Moreover in some trades especially oil markets trading on spot, ships have a tendency to change directions due to arbitrage opportunities, making it difficult to pre-book berths. In some dry bulk markets waiting times at anchorage are beyond industry norms (of around 1-3 days), and sometimes be up to 20 days (Habibi, 2011). Similar problems are noted in the aviation sector where operating practices of airlines prevent them travelling at the speed and altitude for which the aircraft was designed. Omega (2009) link this to airports and air traffic management systems, which for various reasons restrict the cost effective potential (negative abatement potential for CO_2) and short term win-win scenario available for the aviation sector.

4. Analysis of principal agent problem in context of energy efficiency in shipping

Upon identifying the key stakeholders, relationships and main barriers above, it would be appropriate to assume that there are market barriers that continue to prevent optimal energy efficiency. Market barriers in the context of energy efficiency can be broadly understood as 'market-related factors that inhibit energy efficiency improvements' (IPCC, 2001). Many studies have confirmed the presence of such barriers in markets as well as in context of energy efficiency (see for example Jaffe & Stavins, 1994; DeCanio, 1993; DeCanio, 1994; Brown, 2001; Sorrell et al., 2004; Sathaye, 2004; Guertler, 2005; and IEA, 2007). IEA (2007) shows market barriers fall within three categories; low priority accorded to energy efficiency, lack of access to capital and incomplete markets for energy efficiency. Hill (2010) in analysis of barriers in shipping, categorises barriers into four categories namely; economic, technical, structural and regulatory.

Of the above barriers, one that is often cited in literature pertaining to energy efficiency in shipping is the principal agent problem or the issue of split incentives (AEA, 2008, CE Delft et al, 2009, IMarEST, 2010). The principal agent problem according to the IEA falls under the low priority accorded to energy efficiency category and classed as economic barrier. In quantification of the principal agent problem IEA estimates the principal agent affects significant proportion of end-use energy (3800 PJ/year in 8 cases across 3 sectors). Stemming from agency theory, the principal agent problem describes the conflicting actions of the parties involved in a contract, who tend to have divergent goals. As an example the tenant-landlord scenario is often cited. The landlord typically wants to minimise capital costs, hence will not invest in energy efficiency of the building as opposed to a tenant who actually pays the energy costs related to the investment. Therefore the landlord has no incentive to make energy efficient investment as only the tenant benefits from these reduced costs. In some cases where markets are efficient this may not hold, as a landlord who has invested in energy efficiency of his building should be compensated with higher rent. This issue takes us back to the original barrier of how much priority is actually accorded by the market to energy efficiency.

Analogous to the landlord-tenant scenario, in shipping, the principal agent problem (in context of energy efficiency) could exist between a multitude of stakeholders aforementioned e.g. between charterer and freight forwarder, decision to slow steam in laden leg provides benefits for the charterer but may adversely affect the shipper, shipowner hiring a ship manager to oversee the day to day running of the ship. However, much literature has focussed on the ship owner and the charterer. CE Delft et al 2009 and AEA 2008, show that there is scope to reduce emission by 10% cost effectively but measures are not being implemented due to the existence of split incentives. Similarly for aviation, Omega (2009) show that a range of interventions could enable the aviation sector to abate about 12-15% of its CO2 emissions at negative or zero cost by 2012, in a normal fuel price scenario. According to IMarEST "the biggest institutional barrier to implementing energy efficiency measures is the divided responsibility between shipowner and charterer for fuel costs". CE Delft also estimate that bunker costs of about 70-90% of fuel consumed in the industry are typically passed on (although cost pass through alone is not proof for split incentives) e.g. through different charterparties, bunker adjustment factors (BAF) and freight rates that include a portion of fuel consumed e.g. Cost Insurance Freight (CIF) in oil trading.

Figure 5 below briefly represents of the various charterparties existing within shipping and how this translates into responsibility for fuel payments, which may give rise to principal agent problems. In scenario 1 the principal and the agent are the same entity, hence investment in energy efficiency is made by the same person paying for the energy costs. A classical example of this would be some of Maersk's fleet which is owned and operated by Maersk, giving it the incentive to invest in energy efficient ships and technology. In the tanker trade this applies to for example major oil companies, which own and operate a small percentage of their own fleet. However even within the owner-operated fleet, the principal agent problem may still persist if there is an ability to pass on the fuel costs even at times of higher freight rates for example through BAF's (Cariou and Wolff, 2006).

In scenario 2 the principal and the agent are separate entities. The principal (in this case the charterer) who has the ship on a time charter is liable to pay for fuel costs as well as the daily rates to the ship owner (the agent). The ship owner pays for all other costs including canal/port dues, crewing, maintenance and capital costs (refer to appendix). There are two instances of principal agent problem in this scenario. Firstly the ship owner lacks the incentive for investing in an energy efficient ship/technology (minimising capital costs) since the fuel is paid for by the charterer. Secondly the ship owner is in control of operation of the ship (hence liability for all other costs) therefore the 'operation of the ship is not under the control of the party paying for the fuel' (CE Delft et al, 2009). It is partly due to this split incentive coupled with the short/medium time horizon, that most cost-negative abatement measures such as those identified by DNV (2009) are not implemented, around 150 million tonnes of CO2 related to cost negative operations and another 150 million tonnes of CO2 related to technical measures (refer to appendix). Hill (2010) argues this is one of the major drawbacks of marginal abatement cost curves as they tend to assume markets to be homogenous. As mentioned earlier where markets are efficient (perfectly competitive), this assumption may not hold, thus a ship consuming less fuel would fetch higher rates and vice versa. This issue takes us back to the original barrier of how much priority is actually accorded by the market to energy efficiency.

CE Delft argue “that fuel consumption is only one of many factors that impact a ship's charter rate and certainly not the most important one”.

In scenario 3 the ship owner is responsible for all costs pertaining to an individual voyage (voyage charter) therefore initially there is some incentive to improve energy efficiency of a ship. The charterer only pays for the total cost (freight rate $/tonne) which will include some portion of the fuel cost. The level of principal agent problem here depends on the level of cost pass through in different markets and business cycles. When demand for shipping is higher than supply of ships, ship owners can absorb additional costs and when demand for shipping is lower than supply, then costs will be passed through further down the chain (CE Delft, 2010). Scenario 4 illustrates a bareboat/Contract of Affreightment which is similar to scenario 2 except the time period of the charter. Again, there is a high likelihood that principal agent problem occurs here (AEA, 2008) but due to longer time period and bargaining power (through renegotiation at end of contract), the charterer has an incentive to reduce fuel bills through retrofit measures with payback within the investment horizon.

In comparison to the international aviation sector, charters fall mainly into two main categories; long term charter (dry lease) or ad hoc charter (wet lease). Most airlines (operators such as large network carriers, low cost carriers, regional and freight carriers) employ dry charters similar to that of scenario 4 (bareboat charter) as opposed to relatively small percentage employing wet leases analogous to time charter (e.g. business carriers). As seen we have seen it is common practice to place blanket assumptions on the shipping sector with regards to the principle agent problems in context of energy efficiency without due consideration of the heterogeneity in the shipping markets. The ability to pass fuel costs, flexibility on who pays for fuel, impact of business cycles, different charter parties and different sectors (ship types and trades) existing within shipping call for a thorough investigation of the principal agent problem in respect of the heterogeneity of the sectors. Some of the important questions that need to be investigated are:

- Does the principle agent problem really exist, is it limiting the potential for energy efficiency?
- To what extent does adoption of energy efficiency vary between markets (wet/dry/container)?
- How are charterparties set in different markets, what are the variables and which have priorities?
- And ultimately, which stakeholder has the highest level of incentive so as to be targeted as the responsible entity in a mbm?

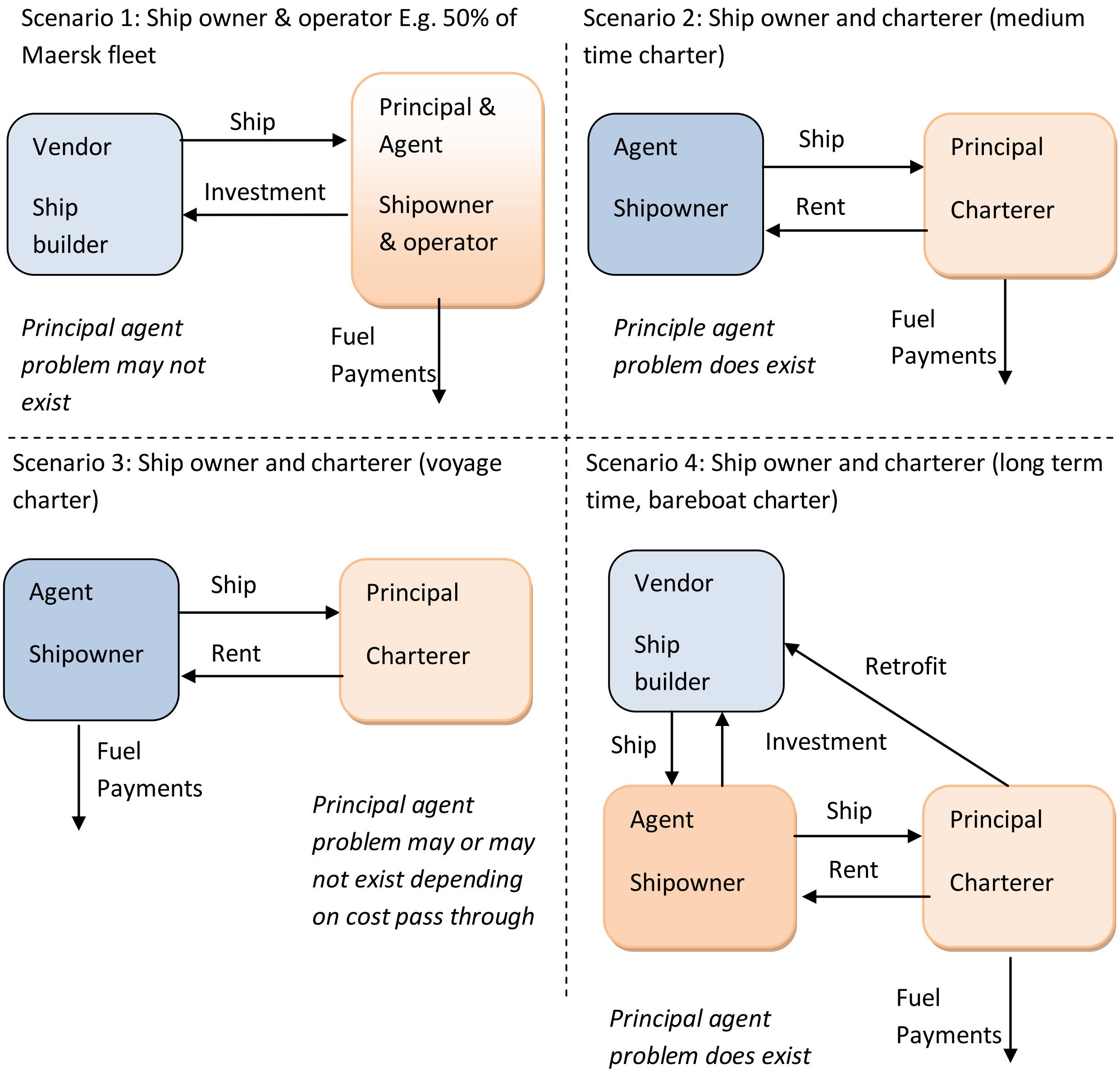

Figure 5: Type of charters in shipping and principal agent problem

5. Application of the Viable Systems Model for analysis of barriers to energy efficiency in shipping

Beer's (1979) Viable Systems Model (VSM) is a systems thinking tool originating from organisational cybernetics (OC, relating to control and communication in organisations). VSM is proposed to be the best known model for modelling organisations, with the capability of designing and diagnosing organisations (Schwaninger and Rios, 2008). It has been applied in many cases for micro level understanding of systems (Nystorm 2006a, 2006b, Devine, 2005, Vidgen 1998) but not limited to such applications (Shaw et al, 2004). In order to find fundamental solutions a system must be viewed as a whole where key leverage lies in the interactions of the parts and not simply one piece (Senge, 1992). Thus, VSM is concerned with a system's essential organization i.e. with what defines the system and enables the maintenance of its identity/viability (Jackson, 1989). Having identified the various stakeholders, networks, markets and many other variables in shipping as well as barriers pertaining to energy efficiency and policies, it is important to view each as a sub set of systems (recursive levels), overarched by a general shipping system.

Beer (1979) defines the five subsystems of a viable system and how they interact to control an organisation. The key roles of the five subsystems are summarised below:

System	Name	Role	Neuro-physiological
Subsystem 1	Operations	Primary activities, core functions, self sustaining processes	Muscles, organs
Subsystem 2	Co-ordination	Resource bargaining and distribution, Conflict resolution	Nervous system
Subsystem 3	Control	Internal eye – Strength and Weaknesses through internal regulation. Efficiency	Base brain
Subsystem 4	Intelligence	External eye – Opportunites and Threats through environmental scanning.	Input from sense
Subsystem 5	Policy	Ultimate authority, Strategy Formulation, Provides certification, ground rules,	Cortex

Table 1: Summary of component roles in a viable system Rehmatulla (2008)

The five systems are further categorized into three main elements. They consist of operations, metasystem and the environment. The operations is where the primary activity of the organisation takes place, the metasystem element ensures everything within the system is working and operating well together and the environment refers to the external environment over which a system has little influence. A fundamental proposition inherent in the theory of VSM is that social systems are structured recursively, which allows us to analyse the structure of systems at many levels, above and below the system in focus. For the scope of this paper the different levels of recursions that can be applied are; at the industry level (shipping industry as a whole), sectoral level (main markets tanker, dry bulker, container, other), sub sectoral (crude oil carriers and products carriers, major and minor dry bulkers etc), business unit level (individual firms in the sub sectoral level) and even lower according to Simon (1969). Since much of the paper has argued for heterogeneous outlook towards the industry, in theory each will have its own VSM but subsystems 1-5 can be referred to being in the same hierarchy for all the levels, so subsystem 5 of the charterer can be compared to subsystem 5 of the shipowner, as well as of the regulator (Shaw et al, 2004). Therefore It is appropriate to look at different business units (broad stakeholder groups) existing within the industry. The system in focus for the purposes of this paper (principal agent problem) is to look at the charterer, shipowner, as separate business units, with particular analysis on energy efficiency and environmental regulation. In order for a system to continue to be viable in the face of environmental requirements, it has to have the capability of adaption (Vidgen, 1998). In this case, the environmental requirements for the shipowners' are meeting the forthcoming mandatory requirements for EEDI, and other annexes to Maritime Pollution (MARPOL) related to SO2 and NOX. The functions of the subsystems of the key stakeholders (business level) in the tanker sector are outlined below (in relation to energy efficiency in different charters):

- Subsystem 1 (operations) - supply of ships (shipowner in voyage, time & bareboat charter) and demand for ships (charterer in voyage, time & bareboat charter), day to day running of ships (crewing, bunkering, complying with MARPOL, etc in control of shipowner)

- Subsystem 2 (co-ordination) – supervision of day to day running of ships, fuel consumed/loaded (shipowner in voyage charter), centralised planning for other activities (e.g. crewing) is higher priority (shipowner in voyage & time charter) supervising day to day activity of ship chartered through daily reports sent by master of the ship (charterer in voyage charter)
- Subsystem 3 (monitoring and control)– continuous stock take of energy efficiency improvements that can be made to ship (owner operated fleet), monitoring for speed and daily consumption to abide by charterparty clauses (ship owner in voyage and time charter) using fuel efficiently, negotiating contracts based on energy efficiency of ships and vetting of ships (charterer in voyage and time charter), retrofitting (charterer in bareboat charter), optimising the charterparty (charterer in time and bareboat charter)
- Subsystem 4 (intelligence) – dealing with environmental regulations such as the EEDI & MARPOL that affect the supply of ships (Shipowner in voyage, time & bareboat charter), searching for energy efficient ships (Charterer in voyage charter) searching for ships that will comply to future regulations (Charterer in time and bareboat charter)
- Subsystem 5 (policy) – establish the approach to shipping, cheap and dirty or clean and pricey (shipowner in voyage charter) establish the approach to shipping by focussing on owning and operating own fleet of ships (charterer in bareboat charter)

Having briefly identified the key roles of the ship owner and charterer in the current state, we can now use the VSM to show how some of these stakeholders' roles, processes, interactions and information flows may change if a hypothetical mbm is added. It is assumed that allowances are grandfathered/auctioned only to responsible entity i.e. the shipowner and they are transferred to charterer under long term time/bareboat charter. The functions of the subsystems of the key stakeholders (business level) in the tanker sector are outlined below (in relation to a hypothetical ETS in different charters) is outlined below:

- Subsystem 1 – supply of ships (shipowner in voyage, time & bareboat charter) and demand for ships (charterer in voyage, time & bareboat charter), day to day running of ships (crewing, bunkering, complying with MARPOL, surrendering CO_2 allowances, all in control of shipowner) surrendering CO_2 allowances (charterer in time/bareboat charter)

- Subsystem 2 - supervision of day to day running of ships, daily fuel consumption/bunkering operations (hedging), trading of allowances, allocation of allowances to ships, invoicing charterer for additional CO_2 cost (shipowner in voyage charter), supervising day to day activity of ship chartered through daily reports sent by master of the ship (charterer in voyage charter), optimising the charterparty (charterer in time and bareboat charter)
- Subsystem 3 - continuous stock take of energy efficiency improvements that can be made to ship e.g. cost savings shown by DNV (2009), (owner operated fleet and shipowner in voyage charter), monitoring for speed and daily consumption to abide by charterparty clauses (ship owner in voyage and time charter) using fuel efficiently, negotiating contracts based on energy efficiency of ships and vetting of ships (charterer in voyage and time charter), retrofitting (charterer in bareboat charter)
- Subsystem 4 – sell/scrap ships that are consistently exceeding allowances when costs are borne by owner, buy ships on the basis of profiting from surplus allowances (shipowner in voyage charter), renegotiation of ship charters on the basis of allowances supplied by shipowner (charterer in time and voyage charter), constant outlook towards energy efficient ships and tightening targets for emission reduction (shipowner and charterer)
- Subsystem 5 – decisions whether to or not to prioritise energy efficiency of ships (shipowner in all markets), establish the approach to shipping by focussing on owning and operating own fleet in order to be in control of CO_2 emissions and allowances (charterer in bareboat charter)

5.1. Discussion

Any mbm, be it a levy or ETS will have to target/incentivise a responsible entity, the same way as the EEDI targets shipowners and ship yards (back end of the supply chain). CE Delft et al (2009), in their analysis of several policy measures identify seven probable stakeholders (the registered owner, ship operator, ship manager, charterer, consignee, fuel supplier and the ship itself). The nature of the industry is such that each of these may change even during a single accounting year, making it difficult to enforce and monitor an mbm. Norway's proposal for global ETS (IMO 2010b) makes the ship the responsible entity, therefore any party interested in its operation will have the incentive to pay for its emissions. Nonetheless if we assume the shipowner to be the responsible entity (CE Delft approach), how much change will we see? As previous discussion has illustrated, there might be no change at all due to the principal agent problem existing in a large part of the tanker sector. Cost pass through rates in the industry is of paramount importance, they have been brought up many times at the IMO discussions and recently in the intersessional meeting for GHG meeting, China followed by its non-annex i counterparts claimed that in shipping its the final consumer that pays the costs. Costs can be related to inefficient operations as well as additional CO2 prices (IMO, 2011).

In the operations (subsystem 1) we see that under the voyage charter the shipowner will subsume most of the responsibility in relation to the running of the ship and when an ETS is in place, also be the responsible entity for the emissions, hence surrendering allowances. Since the shipowner is liable for bunker costs, which account for around 30 - 50% (Lloyds list, 2010; Stopford 2009), then one would assume that there is a high incentive for reducing this cost item through fuel saving technology or operations. Two key points emerge that may explain the inaction; the cost profile and the number of cost items the shipowner is responsible under this charter is quite high and therefore the priority to energy efficiency may be dampened e.g. focus on capital repayments, which account for roughly 40 - 50% for ships 5-10 year old ships, in contrast to fuel costs which account for 25% for the same age category (specific sample of capsize bulkers, Stopford, 2009). Secondly, the inaction may be due to the level of cost pass through seen in the markets. Vivid economics (2010) through econometric modelling estimates that cost pass through in South Korean oil markets is around 111% and about 73% for US crude oil markets, which suggests that there is a likelihood that the principal agent problem exists in this market. This poses a paradoxical challenge for policy makers as to what should be the optimal level of carbon price so as to induce change within industry without the burden being borne by final consumers. Furthermore throughout much of this paper, the principal agent problem showed that the charterer (the principal) is the responsible entity in paying for fuel bills under the time and bareboat charterer. Although this may be contractually the case, the charterer will also not bear the costs of fuel and pass along the cost to the shipper, and as such the principal agent problem is transferred, as illustrated below:

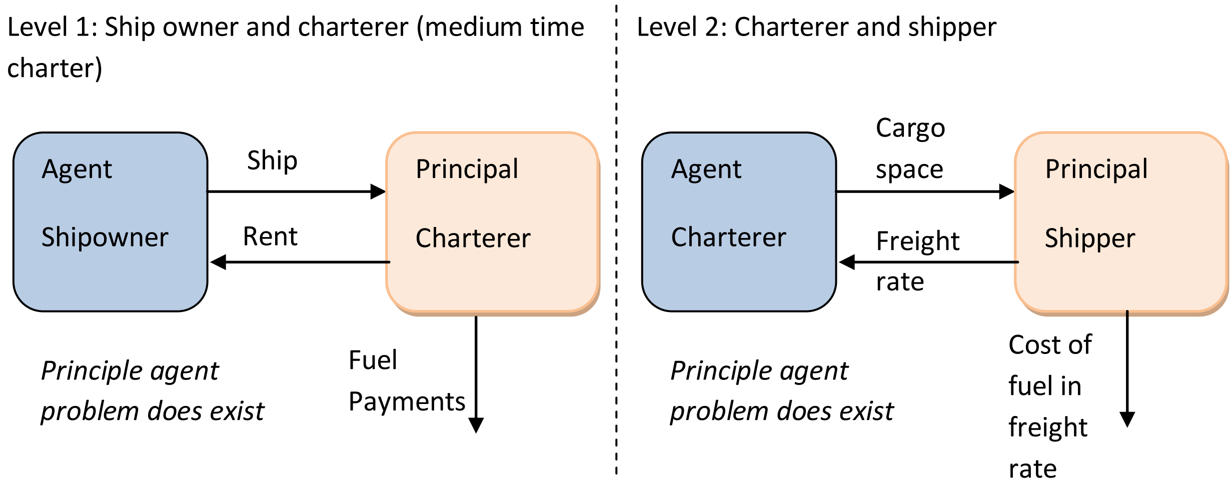

Figure 6: Levels of principal agent problem

If energy costs are paid by the shipper (indirectly through freight costs), then the agent who is now the charterer has little incentive to improve the energy efficiency of the ship on charter. According to Lloyds List (2010) after inventory costs that account for 52%, the next biggest cost item for shippers is fuel costs accounting for 26% of the total costs, followed by 10% capital costs. This may suggest that shippers have the incentive chose fuel efficient ships over inefficient ones. However this priority may be blurred because the shipper seldom sees the fuel cost/energy efficiency of the ships on which its cargo travels, as well as being focussed on reliability of service, transit times, inventory costs. To some extent the industry in general has moved towards transparency and Carbon War Rooms Shippingefficiency.org and Clean Cargo Working Group are prime examples of this. Much of this information from the environment is the function of Subsystem four of the VSM, and in the context of shipowners deals with environmental regulation and decides on how much priority is actually accorded to energy efficiency. This may mainly come from membership of ship owner associations such as International Parcel Tanker Association (IPTA), Intertanko, Intercargo, etc, which actively participate in the regulatory body (IMO) committees. Thus the level of interaction with external environment at higher levels largely depends on these organisations and their interaction with shipowners metasystem to promote energy efficiency.

Voyage Charter					
Stakeholder	Subsystem 1	Subsystem 2	Subsystem 3	Subsystem 4	Subsystem 5
Ship owner	supply of ships, day to day running of ships inc. Fuel	Supervision of day to day running of ships, fuel consumed/loaded, Centralised planning for other activities (e.g. crewing, routing) Charter party arrangements	Monitoring for speed and daily consumption to abide by charterparty clauses	Dealing with environmental regulations,	Establish the approach to shipping
Charterer	Demand for ships, Pays for daily rates Charterparty arrangements	Supervising day to day activity of ship chartered e.g fuel consumed.	Using fuel efficiently, negotiating contracts based on energy efficiency of ships and vetting of ships	Searching for energy efficient ships	Establish the approach to shipping

Voyage Charter in a hypothetical ETS					
Stakeholder	Subsystem 1	Subsystem 2	Subsystem 3	Subsystem 4	Subsystem 5
Ship owner	supply of ships, day to day running of ships inc. Fuel and surrendering allowances	Supervision of day to day running of ships, fuel consumed/loaded, Centralised planning for other activities (e.g. crewing, routing) as well as trading of allowances, allocation of allowances to ships, invoicing charterer for additional CO2 cost Charter party arrangements	Monitoring for speed and daily consumption to abide by charterparty clauses	Dealing with environmental regulations, Fleet management (Sale & Purchase) according to energy efficiency	Establish the approach to shipping
Charterer	Demand for ships, Pays for daily rates Charterparty arrangements may or may not include responsibility for CO2 allowances	Supervising day to day activity of ship chartered e.g fuel consumed. Optimising charterparty if responsible for CO2 costs	Using fuel efficiently, negotiating contracts based on energy efficiency of ships and vetting of ships	Searching for energy efficient ships, renegotiation of ship charters on the basis of energy efficiency	Establish the approach to shipping

Table 2: System roles of shipowner and charterer under voyage charter contract

Conclusions

Perhaps the largest opportunity for significant energy efficiency and C02 reduction lies between shipowner and charterer. The divided responsibility for fuel costs existing between the two stakeholders arising from different types of chartering arrangements prevalent in the industry is an institutional barrier that needs to be overcome. In many cases standard charterparties are outdated and not focussed on energy efficiency (CWR, 2011). An example of such modification was provided, 'Virtual Arrival' which showed firstly the existence of non energy efficient practices at least within the tanker industry and secondly showed potential significant savings in trials. This paper has made an attempt to understand these barriers by applying systems thinking approaches, to structure the problem and provide a holistic view of the situation. Stakeholder mapping allowed the whole supply chain and actors involved within it to be captured. Upon identifying the key stakeholders, economic theory of the principal agent problem was discussed, which showed that the problem may be affecting a significant proportion of end-use energy. Further quantification and analysis of the principal agent problem in shipping may provide policymakers at the IMO with valuable insights into the significance of the problem, where necessary, guidance on implementing additional policy measures to overcome these market barriers to energy efficiency and assessing the effectiveness of policy measures in light of the barrier. We saw that shipowner will invest in energy efficiency measures when regulated and unable to pass on the costs, whereas a charterer theoratically will invest in energy efficiency when has the ability to do so (dependent on the type of charter), thus an mbm might be less of an incentive for a charterer than a shipowner, at least in some markets. The time horizon element is crucial for investments and probably one of the reasons why uptake of many cost saving measures are not being undertaken. This calls for further decomposition of marginal abatement cost curves to reflect these market variations, may be through a series of macc's for e.g. for tanker sector in voyage charter, dry bulk sector in bareboat charter etc.

VSM analysis briefly described the system processes at different levels existing between the shipowner and charterer. Using the information from preceding sections, each stakeholders subsystem roles are viewed in order to see where the principal agent problem is rooted. It is found that lower level sub systems of shipowner operating in voyage charter/spot markets are primarily focussed on basic delivery of service without much priority accorded to energy efficiency. When an mbm is introduced depending on the nature of the market the costs might be borne or passed through. Charterers in all charter markets on the other hand have their lower level sub systems in theory focussed on energy efficiency, (provided costs are borne by the charterer and not simply passed on). Further research is required here to assess the level of cost pass through between charterers and shippers and to final consumers. Moreover to answer some of the questions posed earlier, verify the assumptions and to gain a fuller understanding of the shipping markets for the investigation of principal agent problem, a methodology combining systems thinking methods and generic social research methods is required. This combination has very rarely been applied with only a handful of papers and postulates a methodological paper currently being worked on.

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Appendix

Cost Allocation in different types of charter existing in shipping

Cost element	Voyage charter	Time charter	Bareboat charter
	$/tonne	$/day	$/day
Cargo Handling			
Load port			
Discharge port			
Voyage Expenses			
Fuel			
Port dues			
Canal dues			
Operating expense			
Crewing			
Stores & lubes			
Repairs			
Surveys			
P&I/insurance			
management			
Capital costs			
Interest			
Dividends			
Debt repayment			

Charterer	
Ship owner	

Marginal Abatement Cost Curve for shipping in 2030