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Analytical review of market-based measures for reducing marine GHG emissions and the impacts on the Chinese shipping sector

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ANALYTICAL REVIEW OF MARKET-BASED MEASURES FOR REDUCING MARINE GHG EMISSIONS AND THE IMPACTS ON THE CHINESE SHIPPING SECTOR

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation: **Analytical review of market-based measures for reducing marine GHG emissions and the impacts on the Chinese shipping sector**

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Perhaps, the ship-based emissions are the last major pollutant to be regulated, especially under the pressure of Post-Kyoto requirements. This dissertation is a study of economic implications of MBM and its impacts on the Chinese shipping sector.

An overview of international environmental framework is examined for the purpose of introducing regulatory measures, and the two prevailing MBMs are scrutinized to lead the subsequent focused discussions from the market-based point of view.

The GHG emissions reduction is an economic issue, and the achievement may not be significant by merely relying on regulatory measures. Environmental economics can evaluate the effectiveness of MBMs and collate which type is best to undertake.

The emissions inventory carries an important role in providing quantified figures and revealing uneven emissions allocation due to the phenomenon of "carbon leakage".

The present and future demand and supply in the Chinese shipping sector are evaluated by using economic theorems in order to make an analysis of MBM impacts. The conclusions are addressed on the basis of a recent statistical dataset.

KEY WORDS: MBM, GHG, emissions reduction, inventory, China, shipping sector

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LIST OF ABBREVIATIONS

BDI	Baltic Dry Index
CBA	Cost and Benefit Analysis
CEA	Cost-Effectiveness Analysis
COP	Conference of the Parties
CMC	China Ministry of Commerce
C/P	Charter Party
DWT	Deadweight Tonnage
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
EU	European Union
ETS	Emissions Trading System
FSC	Flag State Control
GHG	Green House Gas
GSP	Green Shipping Practice
IEA	International Energy Agency
IMO	International Maritime Organization
IOPC	International Oil Pollution Compensation Funds
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Developed Countries
LLDCs	Land Locked Developing Countries

MBM	Market-Base Measure
MB	Marginal Benefit
MC	Marginal Cost
MEC	Marginal External Cost
MEPC	Marine Environment Protection Committee
MARPOL	International Convention for the Prevention of Pollution From. Ships, 1973 as modified by the Protocol of 1978
NGOs	Non-Governmental Organizations
NSB	Net Social Benefit
OC	Opportunity Cost
PSC	Port State Control
R & D	Research and Development
SECAs	SOx Emissions Control Areas
SEEMP	Ship Energy Efficiency Management Plan
SFOC	Specific Fuel Oil Consumption
SIDSs	Small Island Developing States
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade And Development
UNFCCC	United Nations Framework Convention on Climate Change
WG	Working Group
WTP	Willingness to Pay

CHAPTER 1

INTRODUCTION

1.1 Climate Change – A challenge for IMO too!

The theme for the 32nd celebration of World Maritime Day[1] was: *Climate Change – A challenge for IMO too*! Unambiguously, this is a clear message to draw worldwide attention that IMO will be heavily and consistently engaged in the fight to protect and preserve our atmospheric environment on behalf of the maritime industry. Since then, substantive focused studies have been energetically and systematically carried out within the organization. Even though the international shipping is, by far, the most energy-efficient means of transporting goods compared to other modes of transport, the resulting emissions will inevitably contribute to climate changes due to the long-lasting effects of CO_2 in the atmosphere (Buhaug., Corbett., Endresen., Eyring., Faber., Hanayama., Lee., Lee., Lindstad., Markowska., Mjelde., Nelissen., Nilsen., Pålsson., Winebrake., Wu., Yoshida., 2009, p. 1). Therefore, the success in combating unwanted GHG emissions from the global shipping sector depends on the contribution from every participant in the sector and the way how they behave in recognition of the importance of GHG emissions reduction. As far as international

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[1] The IMO web site gives further information on courses: http://www.imo.org/MediaCentre/NewsMagazine/Archives/Pages/2009.aspx.

treaty is concerned, the Kyoto Protocol failed to include the maritime GHG emissions. However, this may not be the case in the scope of the Post-Kyoto Protocol due to an increasing pressure from other organizations (e.g., UNFCCC, EU…) and the public as well. Since IMO has determined to work together with other parties or organizations and to play the part with seriousness that circumstance demands, all available means derived from both regulatory and market-based approaches have to be taken into consideration to curb GHG emissions. IMO is, therefore, working quite hard to find better solutions for the domain where it is responsible.

Currently, there are three pillars in the IMO itinerary of the green shipping concept, respectively technical, operational, and market-based. The first two have already become mandatory measures and have been adopted by Parties to MARPOL Annex VI in MEPC 62nd session on 15 July 2011, whereas the MBM is still void and subject to further discussions. This dissertation takes the opportunity to focus on IMO prevalent studies and debates on MBM emissions reduction, and carries out an in-depth research on how MBM will work and what the impacts will be subsequently associated with the Chinese shipping sector.

1.2 Objectives of research

The primary purpose of this research is to illustrate what the prevailing MBMs are and how they work in accordance with the IMO nine fundamental principles[2] of marine GHG emissions reduction. The subsequent objective will be embodied in the impacts how MBM could potentially affect the Chinese shipping sector. In attempting to make this dissertation concrete and convincible, the environmental economics has also been taken on board for illustrating the feasibility of the MBM approach and the methodologies that cope with MBM policy-making.

[2] See Appendix A, table (2).

1.3 Methodology

The relevant literature was widely reviewed beforehand, including appropriate IMO documents and circulars, international conventions, articles from contemporary journals, books and information from websites. Opinions were exchanged and advice was taken by visiting various shipping entities during field-study trips. Furthermore, the secondary resources and statistical figures provided the necessary datasets to carry out a qualitative research, which is mainly used in addressing the main points of this dissertation. The publications relating to land-base GHG emissions control are also referred to abstract the common methods and strategies for both in-sector and out-sector emissions control requirements.

1.4 Structure of dissertation

This dissertation consists of six chapters followed by two appendices. Chapter two discloses the necessity of the research by introducing an international environmental framework and IMO's progresses, scrutinizes two prevailing MBM proposals, and highlights the appreciation of developing countries' participation in the present GHG emissions reduction regime. Chapter three provides an economic analysis in the course of MBM policy-making, emphasizes the relationship between economics and the environment, and then concludes the CBA method for evaluating the effectiveness of the decisions that are finally made. Chapter four structures an overview of emissions inventory methodologies, presents the uneven allocation of CO_2 emissions due to the phenomenon of "carbon leakage", and summarizes the salient features of the Chinese shipping sector from viewpoints of import and export. Chapter five mainly concentrates on the MBM impacts on the Chinese shipping sector by using the law of supply and demand and price elasticity. Finally, the last chapter discourses the overall summaries and conclusions.

CHAPTER 2

International Environmental framework of GHG emissions reduction

2.1 Introductory remarks

Over the past decades, the advanced technologies and systematic procedures in management are providing a staunch foundation in ensuring safety at sea. However, apart from focusing on the safety of the ship and safe carriage of the goods thereof, the concerns in maritime transport are concurrently shifting to environmental issues. Although, it has been proven that nothing could stop the size of a ship from being gigantic, *e.g.*, the contemporary giant containerships of Triple-E class ordered by MAERSK LINE[3], it seems to be problematic when ships are turned into "green" to the environment. Such environmental issues as resource depletion and pollution caused by shipping activities, which the public have been concerned with, have been growing rapidly in the face of globalization relating to business activities (Rosenthal, 2009). Therefore, shipping firms have to be well prepared for the new opportunities and challenges in today's global economy, and many of them have already started to respond to the concerns from the public by embracing green shipping practices (GSPs) to green both their ships and managerial operations (Lai., Luna., Wong., Cheng., 2011).

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[3] The Lloyd's List web site gives further information on courses: http://www.lloydslist.com/ll/sector/containers/article356648.ece

Having considered the importance of environmental concerns and likely trends in the near future, the need of establishing an effective framework is in essence guiding the parties involved on what are supposed to be pursued. Even though the success of being as an environmentalist in shipping can be achieved in one way or another, the necessity of providing an international framework is of utmost importance in terms of efficiency within the maritime industry. It should be appreciated that IMO is rather active in deliberating a proper way of establishing such an environmental framework, *inter alia,* by different approaches from three main pillars, namely technical, operational, and market-based. The content of this chapter firstly gives an overall description of IMO's progress of the subject matter, *ad hoc,* intensive wording will be emphasized on what main MBMs are proposed and how the prevailing MBMs work with regard to GHG emissions reduction in the maritime industry. After that, the necessity of developing countries' participation will be highlighted in recognition of day-to-day importance in the world seaborne trade.

2.2 Environmental framework of IMO

Being the specialized agency of the UN with the responsibility for safety and security at sea and the prevention of marine pollution from ships, IMO has been energetically pursuing the limitation and reduction of GHG emissions from international shipping for years. The tremendous impacts on climate changes have created vast room for expertise from IMO to organize and conduct analytical research on what the best measures are and how they are best undertaken to minimize the GHG emissions in worldwide shipping activities. Although the emissions into the air have only lately been under consideration of the MEPC since 1990 (Bode, 2002), IMO's activities concerning environmental issues have so far centered on marine pollution. Historically, the maritime sector received more attraction from the publicity in its remarkable transporting capacity than the GHG emissions which are now being critically blamed. In recognition of the importance of establishing an environmental framework, some constructive approaches and conferences have been progressively and successfully carried out. As a result, the framework of GHG reduction aiming at an international level is considerably developing from an infant stage of recognition towards a more matured stage of operation.

International negotiations on climate change started in the late 1980s and resulted in the signatory of a Framework Convention on Climate Change (FCCC) at the UN Conference on Environment and Development in 1992 (Bode, 2002). Subsequently, the well-known Kyoto Protocol, which was the first binding agreement in committing the objective of GHG emissions reduction, was the outcome thanks to the collaboration of UNFCCC. The Kyoto Protocol, which is regarded as the initial step towards a comprehensive global GHG regime, has also illuminated the maritime sector on where the shipping future goes. Notwithstanding, UNFCCC was the first UN organization to appeal global attention on climate change and to address adverse effects if no action was taken against it. Exceptionally, aviation and maritime sectors were exempt from the liability under the Kyoto Protocol. Therefore, the two UN specialized agencies had been perceived as outsiders since then (Oberthuer, 2003). Be it as it may, the IMO has been thereafter updated adequately in terms of GHG emissions reduction in the maritime sector and also kept pace with the global green campaign. The birth of the first international convention for regulating air pollution from ships can be dated back to the 1997 MARPOL conference, where the MARPOL Annex VI, "*Regulations for the Prevention of Air Pollution from Ships*" was adopted. From then on, the GHG-WG under MEPC has carried on an effective work and their progress has been timely reported to the organization and meanwhile released to the public, which will be introduced in detail hereinafter.

2.2.1 International convention: MARPOL (ANNEX VI)

The air pollution which is the last major ship pollutant to be regulated was addressed on the agenda in the 1997 MARPOL conference and was included in the 1997 MARPOL Protocol. Later on, the protocol was adopted as a new Annex VI of the MARPOL Convention and entered into force on 19 May 2005. The regulations with regards to different air pollutants and/or shipboard operations which are related to air quality are highlighted in Annex VI. Correspondingly, prohibitions made on the emissions of ozone depleting substances, which include halons and chlorofluorocarbons (CFCs), are defined in the Annex VI. In addition to having set limits on sulfur oxide emissions from ship exhausts, the provisions which grant permission of establishing SECAs are also included in the Annex in order to enforce more stringent controls over sulfur emissions, *e.g.*, the Baltic Sea Area was designated as a SECA in the Protocol, and the North Sea was adopted as SECA in July 2005. Furthermore, other than those measures taken against SO_x emissions, Annex VI also sets limits on emissions of nitrogen oxides (NO_x) which are mainly generated from diesel engines onboard ships. It is worth noticing that both aforementioned gases emissions are two general portions of the Kyoto Protocol greenhouse gases[4].

Although IMO can successfully enact regulations, it sometimes may encounter resistance of ensuring the enforcement, *i.e.*, the adoption of environmental policies of controlling air emissions in some member states has been slow due to the lack of the necessary executive power, and the profits optimization is also hampering the progress of adoption if there are apparently no real economic incentives for

[4] The six greenhouse gases under tracked in Kyoto Protocol are: CO_2 (Carbon Dioxide), CH_4 (methane), N_2O (Nitrous Oxide), SF_6 (Sulfur Hexafluoride), HFCs (Hydrofluorocarbons), and PFCs (Perfluorocarbons).

shipowners to invest in energy-efficient ships. Nevertheless, the scope with respect to GHG reduction had been touched upon in Annex VI. It had definitely rippled in the arena where the impacts of emitting GHG were remorselessly ignored due to economic driven forces. In light of restraining unpleasant emissions from sea transport, MARPOL ANNEX VI is at least deserved to be applauded for being the first protocol relating to marine emissions control in the IMO environmental framework. It is also used for sending out the messages of IMO's ambitions of being green, so some subsequent research and work were whereupon carried out.

2.2.2 Regulatory measures: EEDI and SEEMP

It is evident that the floor had been opened for inviting more contributions on workable emissions reduction measures since MARPOL Annex VI was published. However, the Annex itself is subject to consecutive updates and being revised whenever new effective methods are conceived. Till now, some integrated working plans with regards to GHG emissions reduction have already been worked out both from technical and operational points of view. It is theoretically correct that the energy efficiency will be improved if the same quantity of work is done by using less energy. In the comprehension of such philosophy, a wide range of options which are contingent on the ship's design and operation are available for promoting the energy efficiency. Any decisions with respect to installing efficient equipment or machines will believably promote the vessel's capability in energy saving. Other than improvements made by technology, not forgetting the strategic and efficient operations from both shore base and shipboard, are also rather positive in giving credits of energy saving as well.

Regardless of the type and size of ships which are being built or going to be put in the orderbook in the shipyard, EEDI that has been conducted by means of trial application by IMO since 2008, will be fully implemented in order to stimulate the initiatives for innovations and technical development of all elements influencing the energy efficiency of a ship from its design stage. There are many ways of defining EEDI efficiency, one of which can be simply understood to minimize the ratio of installed power multiplying specific fuel consumption over capacity multiplying speed in service. The notion of EEDI stimulates the innovations in designing new efficient technology and the interests of shipowners in acquiring whatever is available. Even so, the shortcomings of EEDI inevitably encounter in practical operations, for instance, the ineffectiveness and suspicions that have been evident during the experimental trial of implementing EEDI on smaller ships and VLCCs (Devanney, 2010). However, the EEDI does not incentivize the shipping companies in pursuing energy efficiency as much as market-based mechanism does.

It is safe to say that EEDI was purposely established for new ships from the design stage and hopefully functioning throughout the ship's entire lifespan. As far as the existing ships are concerned, a new regime which is known as Ship Energy Efficiency Management Plan (SEEMP) is established for a company and/or a ship to improve the energy efficiency of ship's operations (IMO, 2009_a). It should be noteworthy that no operations are the same in two different shipping companies and/or ships, *i.e.*, it means each company/ship is supposed to have one individual SEEMP that is based on its own operating or trading characteristics. The plan should cover all respects of the company/ship's daily routines, by taking into consideration improved voyage planning, weather routeing, speed and shaft power optimization, optimum trim and ballast, and improved management of fleet, cargo handling and fuel energy. It is hard to deny that energy-saving can be positively gained by cumulation of small amounts of saving from many unconspicuous improved operations. Anyhow, by the time when the market-based mechanism is effective in the shipping field, the SEEMP would eventually be more welcome than it is now because of the incentives derived from market-based mechanism. In addition to the SEEMP, Energy Efficiency Operational Indicator (EEOI) is also advisory by MEPC 59th session in Annex 20. EEOI is used to assist shipowners, operators and any other parties concerned in the evaluation of the performance of their fleet regarding CO_2 emissions and fuel efficiency.

Table 2.1, which is originated from the Second IMO GHG study, indicates a significant potential for further improvements in energy efficiency mainly by the use of existing technologies and improvements in operations (Buhaug et al, 2009, p. 4).

Table 2.1 Potential improvement in energy efficiency by EEDI & SEEMP

Design (New ships)	**Saveing (%) of CO_2/tonne mile**	**Combined**	**Combined**
Concept, speed and capability	2-50*		
Hull and superstructure	2-20		
Power and propulsion systems	5-15	10-50%♀	
Low-carbon fuels	5-15*		
Renewable energy	1-10		
Exhaust gas CO_2 reduction	0		25-75%
OPERATION (ALL SHIPS)			
Fleet management, logistics and incentives	5-50♀		
Voyage optimization	1-10	10-50%♀	
Energy management	1-10		

* CO_2 equivalent based on use of LNG

♀ Reduction of this level would require reduction of speed

Source: Second IMO GHG Study 2009

On 15th July, 2011, IMO finally stepped forward in the campaign of energy efficiency by adopting the amendments to MARPOL Annex VI Regulations for the prevention of air pollution from ships. Both EEDI and SEEMP are added in Annex VI on mandatory footing. The success of IMO in demonstrating its determination of reducing GHG emissions from shipping, albeit taking much pressure from political caveats, has enabled the shipping to lead in efficiency procurement by surpassing its main rival - aviation. However, after back from revel of celebrating such a significant event, the attention has to be paid to answering how far the EEDI and SEEMP could go in terms of energy saving and what would be next beyond what they can contribute to the shipping (Meade, 2011). It is also curious to snoop how IMO is going to deal with MBM which is so far the last pillar left from IMO's environmental framework and as well as what the effects are if it is adopted in the near future.

2.2.3 Economic measures: MBM

Despite how the regulatory measures will react and success in GHG emissions reduction, IMO is hardly able to consolidate the position as a forerunner in the transport domain by solely relying on the regulatory measures. Apparently, the technical and operational measures are not sufficient to satisfactorily reduce the amount of GHG emissions from international shipping with regards to the growing world trade. Additionally, the GHG emissions reduction by EEDI is only guaranteed to be effective after 2019[5]. Therefore, in lieu of a stand-alone policy solution, a more flexible mechanism, such as MBM, should be drawn into the multi-directional policy solution. In light of offsetting growing shipping emissions beyond which regulatory measures cannot reach and providing fiscal incentive, MBM should be implemented for the purpose of complementing where the regulatory measures fail.

In a broad vision, the MBMs, which are overwhelmingly recognized to be effective in controlling GHG emissions, can be divided into two categories: the *price-control approach* and the *quantity-control approach*. The rudiment can basically be interpreted as follows: in the case of the price approach, it implies that a tax or levy

[5] The Seas At Risk web site gives further information on courses: http://www.seas-at-risk.org/news_n2.php?page=423

is collected from any possibility of emitting GHG so as to set up a fund for promoting energy efficiency in whatever the best way; in the case of the quantity approach, it implies that the credits either for requesting more GHG pollutants or from GHG emissions savings by whatever effective measures on the basis of an agreed cap (or limit) can be traded off in the market where the maritime industry is included. The feasibility of MBMs related to both principles is still in progress of being testified. The ten submitted MBM proposals[6] are being discussed by GHG-EG under MEPC. Yet, the consensus among member states and other NGOs has not reached a common agreement so far. In addition to the study of feasibility, the ongoing hot debates and discussions related to the proposed MBMs are also revealing the benefits and drawbacks from any of the MBMs if so carried out.

2.3 Integrative studies of prevailing MBMs

The idea of MBM is somehow not a novelty to the public. EU-ETS, a vivid example of using the quantity approach (or more often known as the jargon of "*cap and trade*") to control GHG emissions from the power stations and industrial plants in 30 countries (the 27 EU Member States plus Iceland, Liechtenstein and Norway)[7] is well demonstrating the proper use of MBM in regulating GHG emissions. In recognition of the fact that GHG emissions reductions from international shipping could barely be done by technical and operational measures, the need of MBM implementation is more stringent than it was ever before. Furthermore, EU has already warned IMO that EU would have to introduce the MBM for the maritime sector if the IMO was unable to find an effective solution (Corbett, 2009). Particularly, in the wake of the outcome of *COP 15* in December 2009, such

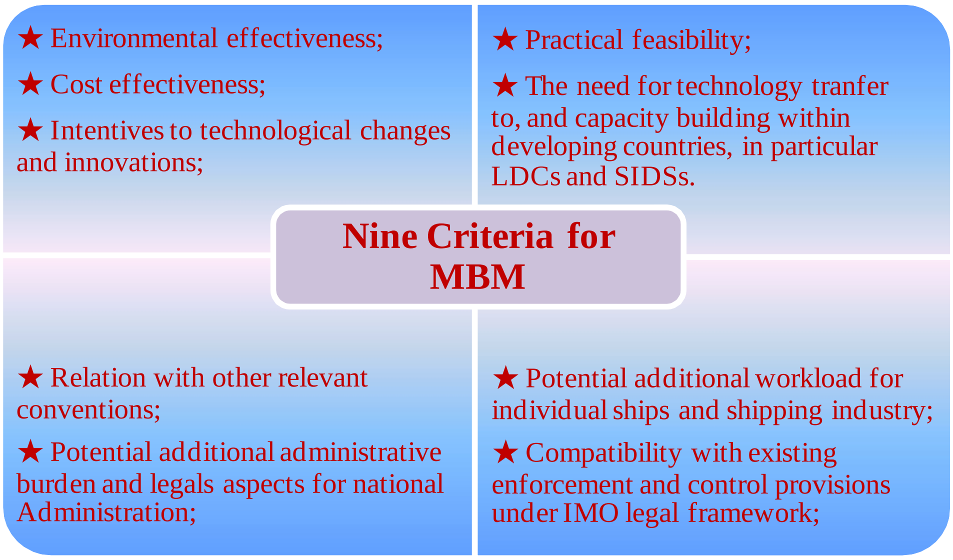
[6] See appendix A, table (1).

[7] The European Commission web site gives further information on courses: http://ec.europa.eu/clima/policies/ets/index_en.htm

intention is becoming more intense.

Prior to assessing the prevailing submissions, nine criteria (see Table 2.2) are taken into account for the evaluation of different proposals. For the sake of convenience, the price-control approach is substituted by the common term "international fund", while the ETS (also called cap-and-trade) is used to stand for the quantity-control approach. Other proposals[8] also set forth independent mechanism or systems of MBM. However, most are more or less similar to the mainstreams. Having considered the gravity of the issues of climate change which is perhaps the most challenging to human beings, no matter which MBM is likely to be chosen by IMO, the purpose of offsetting the excess of GHG emissions from global shipping in contrast to the global reduction target should be properly mat. From the viewpoint of nine criteria of MBM given by an expert group, an in-depth study of mainstream proposals will be thoroughly carried out by taking into consideration from different angles, *e.g.*, rationale and further considerations of robustness if deemed appropriate.

Table 2.2 Criteria for MBM feasibility study



Source: GHG-EG feaibility study on MBM (MEPC 61/INF.2)

8 Supra footnote No.6, at p. 12.

2.3.1 International GHG fund system

2.3.1.1 Rationale

The international fund system has further demonstrated a concrete scheme which is consistent with the UNFCCC objectives or global reduction target and compatible with any future global climate change agreement (IMO, 2009$_b$; IMO, 2010). The registration of the bunker suppliers will be made on compulsory basis for participating parties and on voluntary basis for non-participating parties. Anyhow, the party's ships are obliged to purchase fuel from the registered bunker suppliers. Correspondingly, a contribution to the fund is collected in proportion to the bunker quantity as stated on the delivery note. In the proposal, it is envisaged that bunker suppliers will be held responsible for paying contribution instead of shipowners who are not responsible for bunker supply from time to time. The rate of contribution is subject to variation in order to ensure the funds are available for achieving the agreed target. The allocation of the funds will be adhered to the objective of ensuring GHG emissions above the global reduction target line. Meanwhile, the allocation of funds also goes to mitigation and adaptation purposes with emphasis on developing countries including LDCs & SIDS, administration cost of the GHG Fund Administrator, R&D activities, and for Technical Cooperation within the existing IMO framework as well. If deemed appropriate,

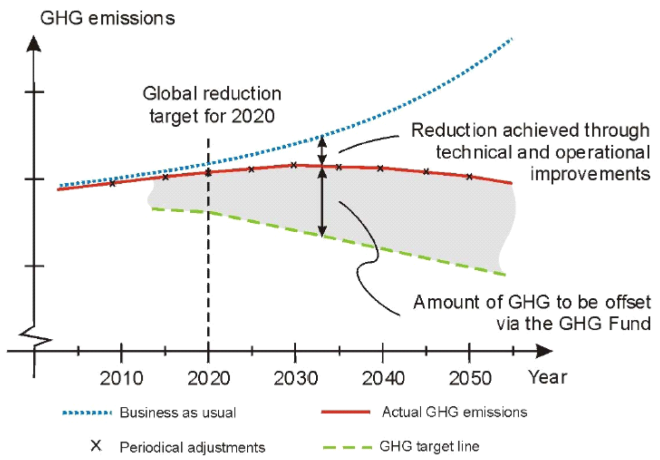


Figure 2.1 A graphic illustration for meeting a global reduction target from 2013 through offsetting
Source: IMO (MEPC 60/4/9)

the Figure 2.1 is rather helpful in understanding how the excess of GHG emissions beyond global standards is offset via international funds.

2.3.1.2 Further considerations

1. In terms of surveillance, the robustness of the system has to be sustainable by cooperation and participation of PSC and FSC for inspections at regular intervals. Nevertheless, what are the best measures to undertake for preventing PSC and/or FSC from being bureaucratic, neglected or fraudulent?
2. Who should be entrusted with administrating the GHG Fund? It might be no problem to have an entrusted team inside the organization to administrate the fund. However, it is impractical that IMO establishes a sub-office in every port where the bunker suppliers work, so then who is going to be entrusted in administration at the site of the port, PSC, FSC, coast guard or local government?
3. The "broken weather" is bound to happen in the shipping market due to the economic "*invisible hand*". The average shipping cycle is around 7 years (Stopford, 2009, pp. 104-131). The shipping market is alternatively changed from rebound to lean or vice versa. The international fund system superficially overcomes the problem influenced by inconsistency of the market, simply because contribution is collected as the fuel is consumed by the ship. However, it would be true that the insufficient fund caused by a depressed shipping market is unable to work out efficient measures in terms of GHG emissions reduction. Ships, therefore, have to face the embarrassment when the shipping market is booming again, either still hanging on with efficiency procurement or deviating out from the slogan. Most probably, the latter choice will be the upper hand since the market is too profitable to lose. The argument in the conclusion is still

going on with suspicions on how far the international fund system could go in the maritime industry.

2.3.2 Emissions Trading System (Cap-and-Trade)

2.3.2.1 Rationale

ETS is basically providing options to participants for trading their credits of allowing GHG emissions. Options are given either by selling the excess of credits saved from efficient measures or by buying credits due to inefficient manners from whoever possesses surplus. The premise of successfully implementing *ETS* is to determine a reasonable cap (or limit) which is used as a benchmark of setting the allowed GHG emissions in the maritime domain. In addition, the cap will be subject to modification for more stringent levels as the time goes along. That is why *ETS* is sometimes also referred to as *cap-and-trade*. Credit which is tradable in this regime is defined as the emissions allowance in terms of quantity. Credits are saved as surplus whenever the quantity of emitting GHG in total is less than the cap. In contrary, credits have to be procured by whichever possible way if emissions are over the cap. The Global *ETS* for International Shipping responds to the need for precise emissions control through the establishment of a *cap* on total emissions from the sector. Meanwhile, it provides for an access to the most cost-effective emissions reduction measures to meet the *cap* (MEPC 60/4/22). In recognition of the importance that ETS may work in reducing GHG emissions, the system of auctioning credits should be systematically established both in the in-sector and out-sector, in order to get more international entities involved in GHG emissions reduction. Because of auction of credit, an enormous amount of money will be accumulated. The monetary purpose of auctions will be more or less the same as the international fund, which is mainly engaged in the mitigation and adaption in developing countries, R & D funds, and technical activities. However, the monetary utilization and availability will only be workable for the states that are willing to join the ETS regime.

2.3.2.2 Further considerations

1. Apparently, the ETS provides a clear objective (*cap*) for the sector, and all participants know how much the gap is by comparing their own capacity with the cap. Therefore, how high the cap is will be the key element of the scheme. The passions of pursuing shipping businesses will be frustrated if the cap is set too stringent, and in other words, participants will not be so serious if the cap is too incompact. Further, not forgetting the unique characteristics of the shipping market which is subject to various cycles. Another question is, should the developed countries and developing countries be equally treated, even though the portion of collected funds will be made available for mitigation and adaption for developing countries?
2. From the experience of other similar schemes, the reluctance was observed in the trading scheme. The participants would like to buy or sell the credits rather than focus on improving emissions reduction. Likewise, the same phenomenon is suspected to occur in the maritime sector. The operators[9] of ships will prefer to auction more credits for optimizing profits and transfer the financial burden to the end-user of ships in the prosperous market. Contrarily, ships emit rather less GHG when the market is in the downturn, and probably the level of the cap will cover the emissions during those periods. It really has to put a question mark here to remember how shipping is incentivized under ETS scheme.
3. The experience of fraud or evasion has been found in the existing scheme; there is no exception in ETS as well. So the administration or registry whatever it will

[9] Users of ships may be shipowners, operators, charterers, or whoever posses the ships for making profits.

be called under the scheme has to find a proper way of ensuring authenticity in an effective manner.

2.4 Participation and Impacts for developing countries

In light of creating a new framework, a balance between economic development and environmental issues is very important (Corbett, 2009). It is the common sense that GHG emissions reduction ought to be leveled up to international participation and collective actions. In this regard, it seems to be ridiculous if any distinct partition in the atmosphere is assigned to which nation should be liable for reducing GHG emissions. From the view of social responsibility, no nation is allowed to be outside of the world wide campaign which aims at lessening GHG emissions. As far as economic impacts are concerned, developing countries are not in the same situation as developed countries are with regard to adoption of a new MBM regime. It is fair to comment that developing countries to some extent should not be equally treated as how developed countries are treated. As mentioned earlier, developed countries have taken the advantage of polluting the air free of charge. However, under the MBM regime, developing countries not only have to pay extra expenses for the emitted GHG caused by economic development per se, but they are also compelled to share the compensation incurred from the past economic activities of developed countries. Based on the above bias, a number of nations claimed to run the GHG emissions reduction policy in accordance with the principle of "common but differentiated responsibility". Some delegations therefore have the view that reduction of emissions related to international shipping should be on a voluntary basis for developing countries (Buhaug et al, 2009, pp.18-21).

Developing countries are being recognized as the main stream in the world's economy. In 2009, developing countries once again accounted for the largest share of global seaborne trade (61.2 per cent of all goods loaded and 55.0 per cent of all goods unloaded), reflecting their growing resilience to economic setbacks and an increasingly leading role in driving global trade (UNCTAD, 2010, p.6). In addition, due to the tax discount or asset play[10] or whatever reasons, the registration of a ship is flexible to move among jurisdictions several times throughout its lifetime. Approximately, three quarters of the world tonnage, by deadweight, of all merchant vessels engaged in international trade are registered in developing countries[11], hence making it a large portion of the world fleet (Buhaug et al, 2009, pp.18-22). It is obvious that any regulatory regime or MBM would ineffectively carry out the task by solely relying on the remaining one quarter of the world fleet. Therefore, the participation of developing countries is indispensable for ensuring GHG emissions reduction on a global basis. In order to accelerate the emergence of an agreed MBM, the initiatives of participation from any developed countries are highly appreciated and valuable for stimulating other nations which are still slow-motion.

The concerns of preserving the environment are easy to agree upon. However, the responses and actions towards to such common consent may be differentiated from country to country due to some barriers of various national conditions. In details, the first barrier goes to the financial endurance of developing countries in investing in “green” ships. Ships tie up a lot of capital, in other words, the ship is capital intensive (Stopford, 2009, pp.270-317). The percentage of newly-built ships from developing countries is considerably lower than the percentage from developed countries (UNCTAD, 2010, pp. 30-60). Technically speaking, an aged ship consumes more fuel than a newly-built ship for carrying the same amount of cargoes, unless specified otherwise. Therefore, developing countries are potentially in the position to pay more

[10] Some ship owning companies are fond of buying and selling of ships by speculating market trends instead of concentrating on the transporting cargoes to make profits.
[11] It includes the countries which are not listed in Annex I of the Kyoto Protocol.

contribution for GHG emissions reduction if they are not differentiated under the regime. Financial burden is the primary barrier and the origin of reluctance of developing countries to be involved.

Secondly, the design and technology that are exclusively used for manufacturing efficient machineries and engines are mostly controlled by some well developed maritime nations. The majority of developing countries step far behind in the issue due to historical and political reasons. Even though developing countries, like China for example, carry out a lot of ship building work, most of which is “assembling” work due to low labour costs. Clearly, knowledge sharing with this regard is almost null and void. Consequently, whatever technology in terms of monopolization that is privileged by few developed nations will make ships owned by developing countries more expensive to be equipped in an energy efficient manner. Somehow, the phenomenon as seen from fast growing R & D activities and enhancement in technology innovations is becoming more independent in developing countries.

Thirdly, barriers can be found in some indirect facilities to shipping, such as the system of logistics and multimodal transport, infrastructure and cargo handling capacity in ports, technical know-how of stevedores, and efficiency of port agents in clearing port formalities, these barriers will cause some side effects preventing ships from being efficient. Developed countries have already got the competitive edges in most of the aspects compared to less developed countries. Profits gained from well established facilities would be used to offset GHG emissions costs. *Inter alia,* this is particularly true with regard to ships which are engaged in domestic trade only. Last but not least, the ethics and political views of policy-makers are worth being concluded as the key element for judging efficiency. As far as a nation’s development is concerned, policy-makers would tend to pay more attention to environmental issues if the nation is already well developed. Otherwise, the priority will be firstly given to develop the nation's economy at the sacrifices of ruining the environment. Historically, those that are so-called developed countries have actually gone through the same path as what developing countries are doing regardless of environmental concerns. As for developing countries, the political leaders or policy-makers are perhaps too busy with paramount matters (*e.g.*, economy and trade, social affairs, and security…) to be interested in making relevant policies. This fact may also result in a slow progress of ratifying a new convention of MBM. In addition, since the ocean-going shipping industry has a global market where carriers of similar ship types compete in similar market conditions, policy options should cover the entire world to ensure fair competition (Corbett, 2009).

2.5 Concluding remarks

Pursuant to the above, an overview of the environmental framework is considerably scrutinized, which focuses on current measures as given from general perspectives of IMO's three pillars, namely EEDI, SEEMP and MBM. Particularly, the MBM has been intensively analyzed with the emphasis made on the rationale and constraints for future implementation. Two prevailing proposals, international fund and ETS, are identically analyzed for the purpose of carrying out main study in the following chapters of this dissertation. As far as policy-making is concerned, the historical success or even failure of any newborn policy is trying to keep policy-makers aware of the effectiveness by implementing hybrid measures of combining both regulatory and market-based approaches. The former might eventually be able to bring down the emissions level to expected value in a matter of time, but at what cost in doing so. How is it benefited from the society, should the economic effects be concerned and applied in measuring how well the regulatory measures go? The answer is affirmative. The command-and-control measure is rather essential for assisting in establishment of an environmental framework. In contrast, the implied economics theorem where appropriate is to reveal how much the cost is in terms of emissions reduction and/or how much the benefit is in terms of human being welfare.

MBM is becoming the next hot issue in the sphere of GHG emissions reduction, which is deemed to be more attractive after regulatory measures are taken on a mandatory basis. Economical analysis is certainly not ignorable in the presence where market mechanism is being scrutinized. To understand the correlation between environmental regulations and economic effects is really a key element for achieving optimal level of emissions control. It is worth noticing that inconsistency does exist if the environment control and economy development occur simultaneously, with particular respects to developing countries where technology and fiscal management are far less qualified than that of developed countries in meeting the optimal level. It would be an inappropriate option if only focusing on one by ignoring the other. Therefore, the aspects of both the environment and economics are identically important and the inter-linkage in between should be reasonably considered by utilizing economic analysis, which is going to be addressed in the next chapter.

CHAPTER 3

Economics in Environmental regulations and regime of MBM

3.1 Introductory remarks

At present, the existence of economics is almost presents in all fields, either directly or indirectly, providing notions of monetary value for pondering on whether it is worth doing so. It is particular the case in the field of policy-making where economics is becoming an unavoidable discipline for carrying out the task (Marechal, 2007). If the economic analysis and impacts are not properly scrutinized in the process of constituting a new policy, the policy-makers and the beneficiaries of such policy will have to taste the bitter consequences in terms of both economics and environment, especially as for the MBM regime which is a globalized subject. As Whitmarsh (1999) claimed, putting a price on the marine environment; the privilege of making free use of *public goods* (*e.g., sea, air …*) for the purpose of sea transport is phasing out, starting to charge from the foregone environmental threats which are visible and localized (such as *oil pollution, ballast water, ship's hull paint …*) to the contemporary targets which are invisible and globalized (*e.g., marine GHG emissions…*). Such potential trend will result in the consequence that behavior of recklessly dumping GHG into the air will be constrained when polluters have to bear in mind how much it costs for doing so. Therefore, a better knowledge of understanding how economics works in the environment will enrich the effectiveness of market-based measures in the realm of GHG emissions reduction.

In essence, the environmental concerns are certainly economic issues. Many economists, *ad hoc,* Holmes (2010) had proven this standpoint by compiling a set of diversified economic models as illustration. As argued by Brown (2001), should more of it happen if energy-efficient technology was cost-effective, in other words, unless some features of environmental economics enable the possibilities for lowering the marginal cost and meanwhile escaping from the liability for marginal external cost at every additional unit of pollution, otherwise more investment in efficiency should happen. Furthermore, Siegfried (2010) also mentioned, over the past years, the use of transferable permits to control pollution has evolved from little more than an academic curiosity to the centerpiece of the international programs to control GHG. How does the economics work with particular respect to the GHG emissions reduction which is attracting more attention than other environmental issues? What economic theorem should be appropriately applied in this realm? What economic analysis and tools are available for further considerations? In the wake of clarifying the MBM effectiveness, this chapter is going to reveal the answers and needs for further studies relating to the topic. In addition, the application of economic theory and analysis in the MBM regime will also be discoursed in accordance with urged requirements of reducing GHG emissions. As Graham (2005) argued, a pure public good is a good characterized by complete non-rivalry and complete non-excludability. The economics as reflected in the GHG emissions reduction is different from traditional economics due to highlights on externality and un-priced peculiarity. The methods of analysis and quantification, *inter alia,* cost and benefit analysis, can provide detailed assessment in order to reach further discussion.

3.2 Implications and features of Economics in Environmental regulations

3.2.1 Economic implications in environment

No one had been bothered by the marine environmental degradation or deterioration during the time when the sailing ships were predominant in the seaborne trade. It was not the case until the fossil fuel was substantively employed for propelling the ships moving through water. As indicated by IPCC Fourth Assessment Report (2007, pp. 36-41), CO_2, CH_4, and N_2O concentrations, which are major components of GHGs, have been markedly increased and far exceed pre-industrial value due primarily to the use of fossil fuel. Thereby, the gargantuan fossil fuel economy was argued to be the root of the most pressing environmental problems and the inability of tackling them (Constanza et al., 1997; Ozkaynak et al., 2002, 2004; Fitzgerald et al., 2010). Truthfully, the efficiency in sea transport was greatly achieved as the speed performance was enhanced. However, the historic significance was cheerfully remarked at that moment for celebrating this great innovation made on the engine, without any expectation of causing many annoying environmental problems in many years later. In other words, while people were enthusiastically pursuing ship's capability of fast transport, the marine environment was silently absorbing whatever side effects were emerged therein.

The tragedy of the deteriorating marine environment had existed anyhow, but only made public shocked when the extent of pollution was over the assimilability of the marine nature, *e.g.*, the oil pollution was perhaps the first fatal environmental damage the public was concerned with only when the dumped oil contaminated the shorelines, beaches or recreation zones, animals or even the human habitat along the coastline. Any form of pollution, no matter how big or small it is, it will not just happen for free. Something has to be sacrificed as compensation to counterbalance the consequences, either in the monetary form or degradation of living conditions and standards or any other forms, which definitely affects people's happiness. Sometimes, the bill that the environment is bidden in enquiry does not require to be paid at the time when pollution occurred, perhaps some time later, but it will ultimately appear. Dramatically, environmental degradation may somehow not be the cause of current problems, but the result of a bad understanding of oneself and the relation to the world and catastrophes for the next generation (Konchak & Pascual, 2005).

It is rational to state that the variety of understanding environmental deterioration is observed in the opinions raised from different perspectives, which is considered as the threat of living by the Public, the humiliation of vanity projects by politicians, and the market imperfection[12] by economists, and so on so forth. Despite of what opinions the public and politician may have, the relevance of measurement in preventing environment from being worsening is more appropriate to attach importance to economic aspects. Even though a word of two in context are offered to retain the biases that environment is ruined by economic activities, it still seems to be unnecessary to make all such activities blamed and dismissed from what economics has achieved when looking from the other side. In fairness to this point, some economic activities may have incidental effects on the environment, whereas some are subject to specific effects (Ashford & Caldart, 2008). By taking a convincing example, the GHG emissions are fair enough to be attributed as an incidental effect to the marine environment due to the fact that sea transport is often repeatedly regarded as the most cleanest mode of transport, plus the greater contribution of sea transport should be reflected in transporting over 90% cargo volume rather than tackle the GHG emissions. In contrast, oil pollution is a specific effect because the

[12] Market imperfection sometimes is regarded as market failure by some economists

majority is caused by human errors and far severer in terms of existence and harms to marine lives. The effects that the environment undertakes might be temporary or in perpetuity, which is very much depending on how thoroughly human beings read the economics in it since the two systems are inextricably linked and interacted. Economic pursuit makes the environment de-qualified in providing essential welfare; while on the other hand, economics also makes the environment protected from human behavior by establishing economic-control approaches. In conclusion, marine environment deterioration is not all what can be seen in oily birds struggling to survive in oil patches along coastlines, or marine lives suffering poisonous substances, or melting ice blocks falling down from Antarctica. Some real reasons have to respond to all these horrendous changes in nature; economics probably could give us the answers.

3.2.2 Features of economics in environment

According to the argument made in Stern review (2006):

> *"The climate is a public good: those who fail to pay for it cannot be excluded from enjoying its benefits and one person's enjoyment of the climate does not diminish the capacity of others to enjoy it too".*

The above sentences depict the unique characteristics of environmental economics which is believably different from traditional economics. As one laconic definition of economics defined by Ma (2002, p. 400) is, a study of *choices* among people's "*unlimited*" wishes given "*limited*" financial and natural resources; however, the "*limited*" natural resources which are subject to the environment are often distorted and taken as "*unlimited*" resources due to the defect of identifying property rights for them. The jargon of "*property rights*" is commonly used in economics with the purpose of providing basic understanding of how a resource is used or allocated and owned by whom. Literally, the word "*property*" is often used to describe the physical resources, including both tangible and intangible forms, *e.g.*, the land and copyright are respectively two typical examples. In a legal context, a "*right*" means an interest that is protected by law from any interference with the enjoyment of the benefits associated with the interest. As far as the term of property rights is concerned in the environment domain, such term is far less applicable to be used in allocating the goods therein, *i.e.*, the sea or the air is owned by nobody, and an efficient ship will be unable to enjoy the greener air if others are not efficient. Most of the public goods that benefit additional users at no cost to society have little possession of their property rights. Ma (2002, p. 401) concluded another economic concept by identifying the *zero marginal cost* that the environmental goods reflect, which means no additional cost is imposed at any extra unit of consumption. In the consequence of following this defect, the market is imperfect due to the fact that failure is unavoidable with respect to allocating the resources in an efficient manner as a perfect market does.

Another essential feature in environmental economics is: *externality*, which is also one of the reasons causing market imperfection. Externality is used to mirror an economic phenomenon when a loss or gain in the welfare of one party is incurred by the behaviors of another party, where the premise of no compensation for the loss is hypothesized. The environmental pollution is always taken as a classic example for further explanation of externality. For instance, any unlawful discharge of pollutants from a ship diminishes the welfare of people who are living nearby, and the people have no way to get their losses paid. The externality will be potentially enlarged if the magnitude of identifying property rights of a good is lessening. In addition to lack of government intervention, imperfect information and competition, externality makes a closed economic system where perfect market work failed in the function as it is supposed to be. One of the most important messages read from the situation where externalities exist is the fact that theory of supply and demand automatically fails to reflect market costs and benefits. Moreover, the notion of monetary value for measuring the loss occurred in the externality is not workable since such effect is hardly priced. It is, however, not always the case that externality only produces loss (or negative externality) to another party. It sometimes creates gain (or positive externality) as well. By giving an example, slow steaming of a ship does not only reduce less GHG into the air, but also saves fuel for the owner, which is good for everybody. Nevertheless, it is still objective to bear in mind that most maritime activities produce negative externality[13]. Several overlapping factors are summarized as the causes of externalities, including the following: (1) an absence of property rights, (2) non-rival consumption and non-excludability, (3) free-rider problems, and (4) high transaction costs (Ashford & Caldart, 2008).

As illustrated in Figure 3.1 for further understanding of the above discussion, presumably, the quantity of GHG emitted from a ship is depicted by the horizontal axis, so that the quantity of GHG emitted is increased as the movement goes towards the right. Curve A which is the negative slope represents the Marginal Cost to *a ship* for reducing any unit of GHG quantity. So, the marginal cost to the ship is going up as its quantity of GHG is reduced from right to left. Correspondingly, curve B which is the positive slope represents the Marginal *Social Cost* that GHG influence. Alternatively, curve B is often known as Marginal Benefits or Marginal “willingness to pay” (WTP or MWTP) to the society for compensation of the social loss incurred. Obviously, such cost will go up as the quantity of GHG is increased. Theoretically, from the classical economics point of view, the optimal amount of GHG emitted is Q_O at the point when the influence caused by an additional unit of GHG emitted just

[13] It is also called as “public bad”, in contrast to a “public good”.

equals to the marginal cost of avoiding it. However, in reality, the shipping company who owns the ship would very much like to maintain the quantity of GHG emitted as close as to Q' since the marginal cost to the ship is trying to attain zero, despite the fact that the marginal social cost would be very high for offsetting the influence incurred to the social individuals. If regulatory and economic controls are made unavailable, no one claims for such high social loss due to the vacancy created by *externality* of the air, unless the ship owner is so noble that he is willing to cease unacceptable pollution rather than make much more profits.

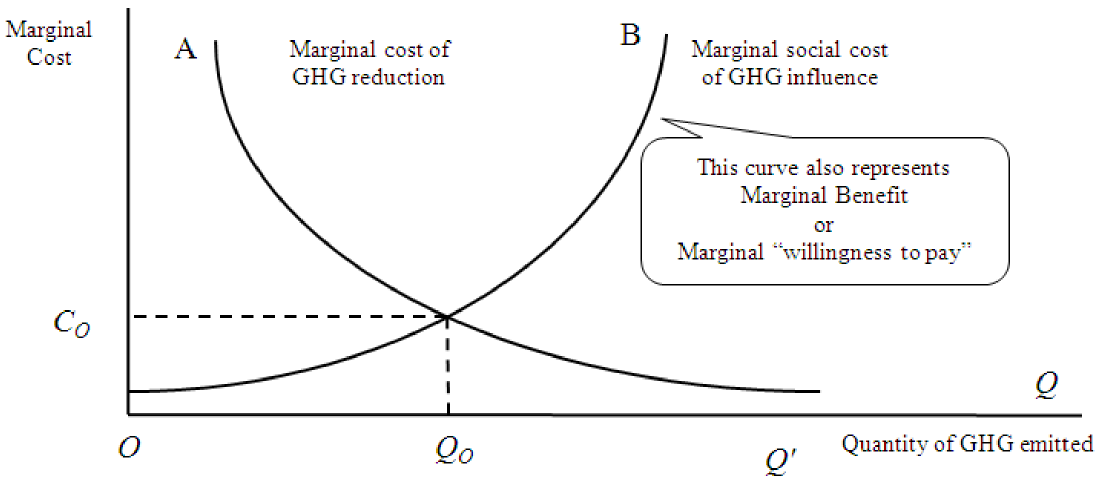


Figure 3.1: Illustration of externality effect in environmental economics

In the recognition of highlighted features of economics in the environment, some constructive approaches are required to be formulated in order to cover the defect of property rights and the impacts of negative externalities. As mentioned earlier, two effective approaches are regulatory and market-based measures. The former is totally relied on government intervention, which is why it is sometimes also referred to as *command-and-control* measure. The latter is derived from the market economic theory which is trying to settle down the raised environmental disputes on a fair basis. Moreover, some studies (Cashore et al, 2002; Falkner, 2003; Wuisan, 2011) have already been carried out on the feasibility and robustness of private governance with a view of greening international shipping. Even though this norm is not full-fledged and still burdened with many restrictions and drawbacks, it is not unlikely that in the future this initiative may help to uncouple the growth in shipping activities from environmental harms (Wuisan, 2011).

3.3 Economics in the regime of MBM

In the past, not only economists did few studies of the environment, but also environmentalists did not pay much attention to economics. When the environmental problems were often exposed followed by major decisions from economic points of view, the two groups of scholars started to realize the inter-linkage and correlation between the two fields. This is also the explanation why little implementation of MBM was discussed in the early stage when foregone environmental issues were concerned. As the time passed, the vital environmental disasters were revealed to be more in the fast economic developments than when it was slow. As a result, the economics was indispensably placed in a very important position in the course of environmental policy-making for the sake of offsetting the social loss incurred from fast developments. Nevertheless, both theoretically and empirically, the coherence of the two subjects provides the enhancement on integrity for a new environmental framework where MBM is also included. In the opinion of mainstream economists who advocate neoclassical economics, the market-based instrument is the most efficient approach to allocate the scarce resources (Graham, 2005, pp. 30-33). In conjunction with the literatures discussed in Chapter two, the economics relating to MBM of GHG emissions reduction will be addressed hereinafter. Subsequently, the discussion of analyzing which MBM is best to be adapted under the given scenarios will be carried out where illustrations are applicable.

3.3.1 Identifying optimal emissions level

The emergence of environmental economics makes mainstream economists un-trapped from the traditional approach and favored in which market-related approach specializes in allocating resources more efficiently. Even though the objective of allocating resources efficiently may come true in the idealized market, it is not necessarily optimal in a social sense in the real world. In other words, the mission of reallocating the social resources in a way that makes someone better off without making someone else worse off is impossible even in the efficient market (Ashford & Caldart, 2008). Under this condition, to consider the ultimate goal of environmental regulations, it would be the one that maximizes a society's total surplus (Ma, 2002, pp. 399-425). For the sake of better understanding, some basic economic concepts should be foremost illustrated before coming to more specific discussions.

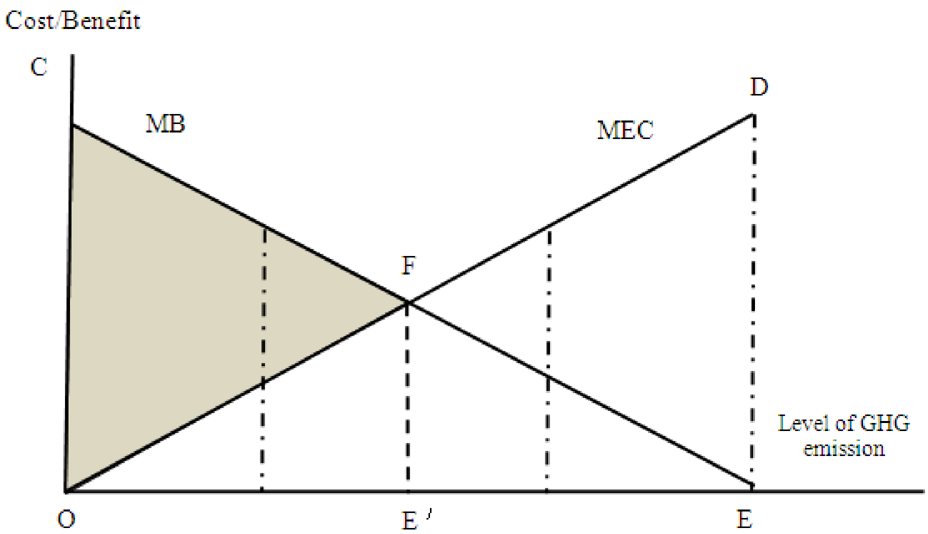


Figure 3.2: Optimal GHG emission level
Source: Shuo Ma, Maritime safety and environment regulations (Grammenos, 2002)

As illustrated in Figure 3.2, by taking GHG emissions control policy as an example, where the horizontal axis represents the level of GHG emissions and vertical axis represents cost/benefit value. As far as GHG emissions are concerned, the *marginal cost* means the additional cost incurred by *a ship* in conformity of new GHG emissions reduction regulations, whereas, the *marginal external cost* (MEC as indicated in Figure 3.2) is reflecting the cost that *the society* has to bear at the same level of GHG emitted by the ship. Obviously, MEC will be higher if the level of GHG emissions is increased. MB means marginal benefit which represents how much society gains at a particular level of GHG emissions. The more GHG is emitted, the less of such gain is attained.

Pursuant to the above briefings, the total benefits that the society gains are described by the area of triangle CEO, whereas the total external cost that the society loses is described by the area of triangle DEO. The social surplus or revenue at the given level of GHG emissions will be the value that total benefits exclude the total external cost, and this is also targeted to be maximized by environmental policy-makers in order to determine an optimal level of GHG emissions. As the level of GHG emissions moves along the horizontal axis from the origin to the right, the revenue or surplus will be initially increased up to a point where diminishing return starts to occur, and this particular point (E′ as indicated in Figure 3.2) is actually the intersection point where MB meets MEC. Therefore, the social surplus is maximum (as indicated by the *shadow* area) at the level of GHG emissions when MB equals to MEC. Correspondingly, the optimal emissions level is identified and a win-win situation is foreseeable for both individuals and the entire society.

3.3.2 Economics in prevailing MBM proposals

The analysis within the ideal modeling seems to be optimistic; the actual situation is, however, far too sophisticated due to the various uncertainties in reality. The discussion on economic applications in the MBM regime will be continued by recalling the two prevailing MBM proposals as scrutinized in the previous chapter, *i.e.*, the international fund system typifying price-control approach *vs.* the cap-and-trade system typifying quantity-control approach. From the economics point of view, which one is superior over the other in GHG emissions reduction? It will not be difficult to discover the answer if characteristics of marginal cost (MC) and marginal benefits (MB) are predictable.

As conceived in theory, MC is in inverse proportion to the level of GHG emissions, whereas MB is in direct proportion. Prior to making any policy, both MC and MB curves are best to depict by considering all factors as far as possible in order to secure an optimal level as a benchmark. However, the presumed curves are subject to variations due to the existence of uncertainties. Depending on the characteristic of the curvature that MC or MB makes, the two scenarios are therefore good for carrying out separated analysis with regards to economic feasibility of proposed MBMs (Ma, 2002, pp. 410-412).

3.3.2.1 Scenario 1: steep MC curve vs. smooth MB curve

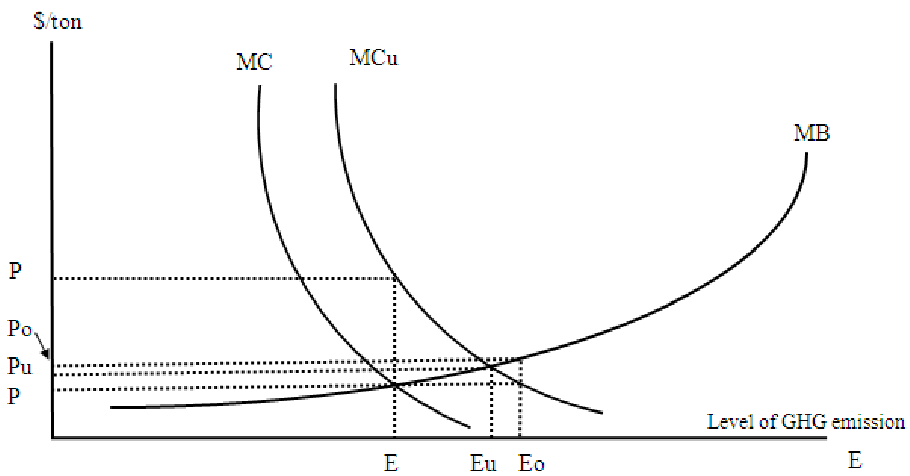


Figure 3.3 (a): Analysis of price-control approach of MBM under uncertainty
Source: Shuo Ma, Maritime safety and environment regulations (Grammenos, 2002)

As illustrated in Figure 3.3 (a), if the price-control approach is primarily used for regulating GHG emissions level, the Price (levy or taxation) will be fixed at point P since it is hypothetically assumed as equilibrium value. In fact, the emissions level at E_u is the real optimal or equilibrium point once all uncertainties are counted on board. As a result, the ultimate emissions level is at point E_o since the controlling price P has anyhow been fixed in advance. Therefore, the difference between E_o and E_u is the extra amount of emissions which is unapprehended by this approach. Alternatively, if the priority of conducting the regulations is given to the quantity-control approach, level E will be fixed in advance. The ultimate cost will be at point P rather than at point P_u, which is the real optimal cost. Explicitly, the gap caused by uncertainty in this approach is much bigger than the one in the former approach. Therefore, it is fair to conclude that the price-control approach is more acceptable and feasible in this scenario.

3.3.2.2 Scenario 2: smooth MC curve vs. steep MB curve

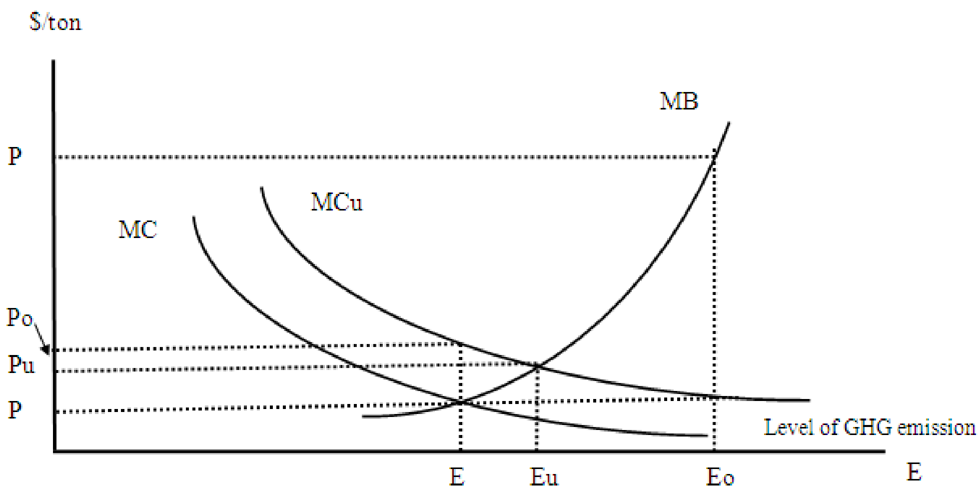


Figure 3.3 (b): Analysis of quantity-control approach of MBM under uncertainty
Source: Shuo Ma, Maritime safety and environment regulations (Grammenos, 2002)

As illustrated in Figure 3.3 (b), the same analysis is also applicable for this scenario, but the only difference is the conclusion that quantity-control approach is testified to be the most effective measure to this scenario. The reason is clearly understood that the rate of change at vertical vector is much smaller than the one at horizontal vector due to the more smoothness of MC curve. Under the unchangeable uncertainties, the prefixed level of emissions which is used as a benchmark in the policy would have least effect on the cost. Contrarily, the price if it is used would have significant effect on the level of emissions.

3.3.3 Summary

Discussions of the two scenarios are purposely separated as to illustrate and compare the different effectiveness of the two approaches under the same condition; however, it does not close the door for any debates and considerations of combining the two. Ma (2002) and Miola et al (2010) claimed that the combination of the two approaches might possibly provide expectation of a more efficient policy in terms of GHG emissions reduction. Up to now, as far as the MBM regime is concerned, the economic concepts are interpreted and incorporated into the analysis. It should be convincing by far that environmental policy-making is a complicated process and also requires an abundance of economics to conduct objective decision-makings rather than subjective wills. The reduction of GHG emissions that MBM targets is really an international goal due to its mobility, different economic status and social sustainability of each participating member state, which deserves to be consulted to determine which type of MBM approach is more relevant, price-control or quantity-control or both. The risk assessment for the final MBM to be taken should be simultaneously conducted in order to ensure that the MBM is not deviating from the economic expectations.

3.4 Approaches of economic analysis in MBM

If half of a task that demonstrates an environmental policy-making attributes to passing through the theoretical derivation, then the other half should be dedicated in quantifying relevant variables to proceed to the next stage with more specific analysis. However, great difficulties are intruding the way of environmental economists converting public goods into monetary terms which can simply be used as a medium to add or compare disparate goods or services. The methods addressed in this section are aimed at contributing ways of how such attempt is achieved.

3.4.1 Cost-Benefit Analysis

Most economists would argue that economic efficiency, measured as the difference between benefits and costs, ought to be one of the fundamental criteria for evaluating proposed environmental, health, and safety regulations (Arrow et al, 1996). An economic approach of Cost and Benefit Analysis (CBA) is widely advocated and believed its outcome could tell the in-depth relevance of environmental goals and economics. As such, CBA is normally taken as an economic instrument to reduce inefficiencies and irrationality in environmental policy-making and to compare favorable and unfavorable effects of that policy. In addition, it is often used to overcome fallacies, such as incorrect priorities, and insufficient control of environmental measures (Hansjürgens, 2004). Nevertheless, the core objective that CBA aims is to determine whether the analyzed program is socially beneficial, in other words, whether the net social benefit (NSB) is positive (Asafu-Adjaye, 2005).

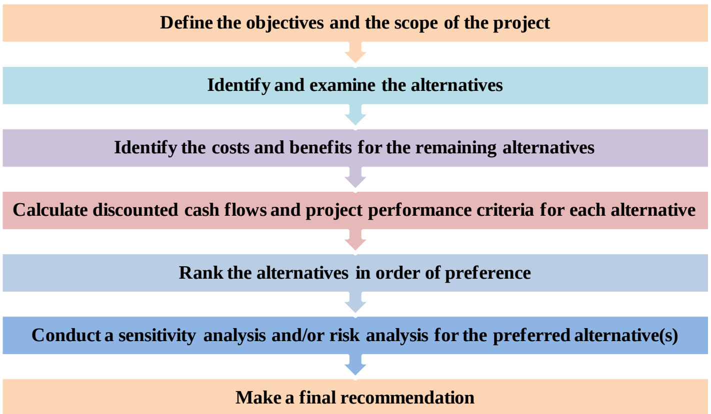
The key success of CBA is to determine the costs and benefits associated with the proposed alternatives within the same regime. Very often, the concept of WTP is used to measure benefits, simply because this concept can reflect the price of goods that a consumer is willing to pay for his satisfaction of consuming it. However, the concept of *opportunity cost* (OC), which also means the "*benefit*" that would have gained from foregone alternatives, is used to measure the cost that incurred in the presence of scarce information. The following formulae will clarify the above:

$$\mathbf{NSB = WTP - OC} \tag{3.1}$$

Accepted if: $$\mathbf{(WTP - OC) > 0} \tag{3.2}$$

The social surplus will be available if the NSB is positive, which also enables the secured compensation for the sufferers if it does occur. Sometimes, NSB is not necessarily positive, perhaps negative, which means the project or policy or regulation is not socially desirable and thus it needs to be revised or abandoned. Basically, the greater the value of NSB is, the higher reliability of the project is foreseeable, or the more surplus is going to be generated. To do so, in the course of CBA, the NSB of each alternative will be accordingly sorted in order of preference, and negative values are of course expelled from the list. Therefore, the priority will be given to the proposal with the NSB which places on top. The CBA is a systematic approach to reach final conclusion by following a sequence of steps which are widely recognized among economists (see Table 3.1).

Table 3.1 procedures of conducting CBA approach



Source: Asafu-Adjaye, J. (2005).

Furthermore, the Benefit/Cost Ratio (B/CR) makes the same conclusion from mathematic point of view. If the information about the annual value of benefits and cost associated with the project over the appropriate time horizon (*t*) is possibly estimated, then B/CR is:

$$\frac{\mathbf{B}}{\boldsymbol{C}} = \frac{\boldsymbol{B_0} + \frac{\boldsymbol{B_1}}{\mathbf{1}+\boldsymbol{r}} + \frac{\boldsymbol{B_2}}{(\mathbf{1}+\boldsymbol{r})^2} \cdots \frac{\boldsymbol{B_t}}{(\mathbf{1}+\boldsymbol{r})^t}}{\boldsymbol{C_0} + \frac{\boldsymbol{C_1}}{\mathbf{1}+\boldsymbol{r}} + \frac{\boldsymbol{C_2}}{(\mathbf{1}+\boldsymbol{r})^2} \cdots \frac{\boldsymbol{C_t}}{(\mathbf{1}+\boldsymbol{r})^t}} = \frac{\sum_{t=0}^{n} \frac{\boldsymbol{B_t}}{(\mathbf{1}+\boldsymbol{r})^t}}{\sum_{t=0}^{n} \frac{\boldsymbol{C_t}}{(\mathbf{1}+\boldsymbol{r})^t}} \tag{3.3}$$

Where, *r* is the discount rate which should be chosen by the decision-makers in accordance with the anticipation as if the project is implemented. There would be three circumstances as indicated by the value of B/CR. If the ratio is exactly equal to *1*, it means zero net benefits will emerge over the lifetime of the project, the discounted benefits would have just compensated to the discounted cost. If it is below *1*, the negative effect would be encountered, *i.e.*, the project will make losses rather than generate benefits. The hedonic result is when the ratio is bigger than *1*, the NSB would be positive since discount benefits is more than discount cost.

The Net Present Value (NPV) and Internal Rate of Return (IRR) are two alternative methods from different angles. They can be briefly expressed as in the following formulae:

$$\mathbf{NPV} = \sum_{t=0}^{n} \frac{\mathbf{B_t} - \mathbf{C_t}}{(\mathbf{1}+\mathbf{r})^{\mathbf{t}}} \quad \boldsymbol{or} \quad \mathbf{NPV} = \sum_{t=0}^{n} \frac{\mathbf{B_t}}{(\mathbf{1}+\mathbf{r})^{\mathbf{t}}} - \sum_{t=0}^{n} \frac{\mathbf{C_t}}{(\mathbf{1}+\mathbf{r})^{\mathbf{t}}} \tag{3.4}$$

$$(\mathbf{IRR}) \quad \sum_{t=0}^{n} \frac{\mathbf{B_t} - \mathbf{C_t}}{(\mathbf{1}+\mathbf{r})^{\mathbf{t}}} = \mathbf{0} \quad \boldsymbol{or} \quad \sum_{t=0}^{n} \frac{\mathbf{B_t}}{(\mathbf{1}+\mathbf{r})^{\mathbf{t}}} = \sum_{t=0}^{n} \frac{\mathbf{C_t}}{(\mathbf{1}+\mathbf{r})^{\mathbf{t}}} \tag{3.5}$$

3.4.2 Cost Efficient Analysis

Although CBA is one of the most widely used forms of policy analysis, it is not panacea, and it is also irrelevant in some circumstances. Empirically, it may be more achievable to set a goal prior to commencing analysis, especially when encountering the problems of inadequate data, lack of funds and insufficient environmental knowledge. Alternatively, the same consideration may be concerned when a number of goals are to be achieved at the limited resources. In this regard, another approach known as Cost-Effectiveness Analysis (CEA) is best to be undertaken in order to resolve constraints in these circumstances. The major difference between CEA and other approaches is that no attempt is made to monetize benefits. Rather, the focus is entirely on meeting a predetermined standard or goal (Dixon et al, 2001).

3.5 Concluding remarks

The environment is encompassing various natural resources that ensure living conditions and enrich social welfare, and it is able to regulate itself in achieving an ecological balance by assimilating natural wastes[14] under normal conditions. The assimilability of nature is the bonus for both human and nature itself to pollute without any cost, *i.e.*, the marginal cost is negative, the NSB is virtually positive even at zero marginal benefit until the assimilability is saturated. Environmental policy-making is not required at all since the virtual NSB positively exists. The pollution derived from nature perhaps knows to stop where it should be, whereas the human's desires and greed of nature exploitation make pollution surpassed nature's assimilability easily. An appropriate policy is therefore required to be analyzed in order to trade-off the exceeding pollution beyond the assimilability. GHG emissions can be taken as a typical example. The greenhouse gases are not new components in

[14] As implied by FIRST LAW OF THERMODYNAMICS.

the atmosphere, but their effects with regards to global warming are significantly addressed until the nature does not have room any more to assimilate the excess of them. Although nature does not tell when NSB is becoming negative, the breathless status of the environment will reveal the truth based on the fact that economics and the environment are closely linked and interacted.

MBM is a new regime which is still claiming for in-depth debates and rectifications among submitted proposals[15]. The content of this chapter provides both economic theory and analysis to scrutinize how an MBM is feasible from an economic point of view. The optimal proposal of MBM should be the one, which is able to generate the maximum NSB, by using the price-control approach or quantity-control approach or the hybrid of the two. The quantitative analysis of all proposals can systematically be carried out in accordance with the procedures of CBA. If where it is inappropriate, CEA is the alternative method for conducting the same analysis. The economic demonstration of each proposal is used to testify the ultimate economic goal under a market model, also the guidelines of commencing an analytical research with a case study in reality is implied. As far as two prevailing MBM proposals are concerned, the rationales have been literarily reviewed and economically analyzed, and the CBA method is introduced, too. The following steps of analyzing the MBM approach should focus on the methodology of emissions inventory and calculation, which will provide essential information from quantified figures. Subsequently, the discussed rudiments and techniques can be used in junction of the real situation and conditions of the Chinese shipping sector, to carry out a more detailed study of MBM implications and impacts on the Chinese shipping sector.

[15] Supra footnote No.6, at p. 12.

CHAPTER 4

Maritime Emissions Inventory and relation with the Chinese shipping sector

4.1 Introductory remarks

Contextually, it has been emphasized that the mission of maritime emissions reduction is really an international and economic issue; the participations of all countries, in particular the developed countries, are therefore highly required to reach a global consensus of reducing GHG in all respects. It is neither realistic nor effective in reaching an optimal reduction outcome if any country lags far behind, simply because of sharing the same atmosphere. Moreover, the mitigation activities to those developing countries are definitely of paramount importance for giving incentives. The necessity of doing so might be intensified due to uneven allocation of emissions in terms of export and import trade for some major "manufacturing" countries, *e.g.*, BRIC[16] countries. China is being widely recognized as the "World Factory" and undertakes many energy intensive manufacturing industries by taking over from those countries which tend to be emission-free. On the other hand, the maritime transport in China has therefore significantly increased in proportion to the growth of the trade, primarily because maritime transport is a derived demand of the trade. However, the inventory of ship-based GHG emissions is essential for both policy-making and efficiency-measuring, whereas it is also subject to variations if the methodological approaches are taken differently, which perhaps will affect the

[16] BRIC countries include: Brazil, Russia, India, and China.

policy-making of MBM as well.

The previous chapter described the bottom line of implementing an environmental policy from an economic point of view, but the theoretical illustration is far easier than the practical execution which should consider the NSB both at global and national levels. Nevertheless, it is quite meaningful to start this chapter by introducing some approaches for estimating emissions inventory of maritime transport from the viewpoint of international trade. One thing leads to another, the salient features of the Chinese shipping sector will be revealed in accordance with the imbalance of the export and import, which may also enable the further discussion on the subject matter.

4.2 Maritime Emissions Inventory

Shipping is estimated to have emitted 1,046 million tonnes of CO_2 in 2007, which corresponds to 3.3% of the global emissions during 2007 (Buhaug et al, 2009). Shipping *does not* remarkably account for global emissions. However, shipping *does* account for a significant portion in the transport sector since maritime transport is playing a major role in this sector (Corbett & Fischbeck, 1997; Eyring et al., 2005a). Empirically, once the IMO has determined the goals of its GHG reduction measures, the next step is often to establish an emissions inventory to conduct a better policy-making, which will provide essential information about the GHG emissions that the maritime transport should be responsible for. Thus, it would be convincible and impressive to make analysis of controlling ship-based GHG emissions if the emissions could be reasonably quantified.

4.2.1 Methodology of Emissions Inventory

The methods of calculating emissions from ocean-going ships are quite different from those used in other sectors. The emissions are also considerably complicated to be captured, especially for the ships engaged in international voyages. The results of emissions inventory, however, may vary as different methodologies are in use. Even though the emissions of ocean-going vessels should be acknowledged worldwide rather than locally, as far as the quantification is concerned, the geographical location is always taken into consideration as a benchmark for comparing regional or national emissions. Generally, the degree of precision derived from the calculations depends on the approach applied, data or statistics availability and selection, and specific objectives of the analysis (Miola & Ciuffo, 2011). Therefore, the primary steps involved in performing an emissions inventory are: establishing an emissions boundary (deciding which emissions sources will be included in the inventory), collecting activity data, calculating emissions and ensuring that quality control measures are in place (Lingl et al, 2010, pp. 10-20). It can be reflected in a simple formula:

$$\mathbf{EI_i} = \sum\nolimits_{\mathbf{i}}(\mathbf{AF_i} \times \mathbf{EF_i}) \tag{4.1}$$

Where *EI* is Emissions Inventory; *AF* is Activity Factor; *EF* is Emissions Factor.

4.2.1.1 Top-down and Bottom-up approaches

Many studies and discussions have been made in the course of quantifying ship-based GHG emissions. The present-day methods of emissions inventory can be divided into two approaches, namely, *top-down* and *bottom-up*. The perception of top-down is also considered as the fuel-based approach (Endresen et al., 2007), which requires overall fuel statistics as the initial impetus for the calculation.

Regardless of the characteristics of the single vessel (such as speed, fuel consumption, engine power, distances and routes), the total emissions will firstly be calculated according to the total fuel consumed, and then subdivided into different categories or types of ships as per the geographical locations or shipping routes. By using this approach, Corbett and Fischbeck (1997), Corbett et al (1999), and Skjølsvik et al (2000) yielded similar results of the annual fuel consumption (*i.e.*, annual GHG emissions). Even though the results derived from this approach were subsequently regarded as unreliable, those first studies have achieved the forethought objectives of illustrating the magnitude of the maritime transport sector's impact on the atmosphere (Miola & Ciuffo, 2011).

The bottom-up approach is a recent-developed method advocating activity-based models. A number of mathematic models have been created and used for emissions inventory calculation by some authors who are in favor of this activity-based method, because it can provide a better basis than fuel statistics for projections of global fuel consumption and CO_2 emissions from international shipping, due to an apparent under-reporting of marine bunker sales (IMO, 2008; Andersen et al, 2010). Eyring et al (2009) also claimed that estimation made by bottom-up approaches was more accurate since the calculation of ship- and route-specific emissions depended on ship movements, ship attributes, and ship emissions factors.

As illustrated in Figure 4.1, the concept and process of the bottom-up (activity-based) approach is straight forward. The fuel consumption of an individual ship is the starting point where a series of calculations follow. However, the fuel consumption with regard to a single ship is divided into different categories, for instance estimations include the fuel consumption made by main engine (ME), auxiliary engine (AE), and boiler on some tankers due to the heating requirements and arrangements. The procedures of calculating each category of consumption, by taking ME as an example, is scrutinized as follows (Buhaug et al, 2009; Eyring et al, 2009):

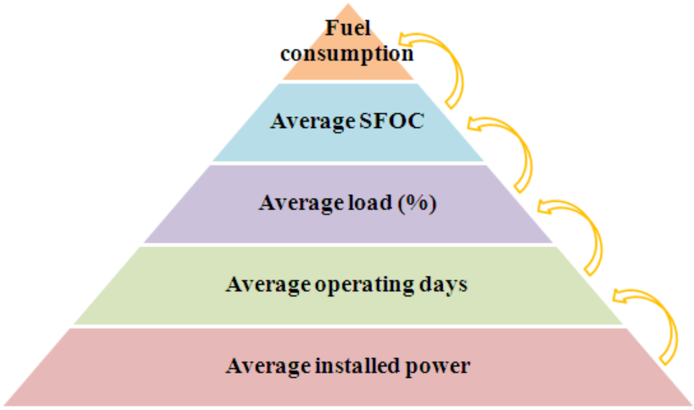


Figure 4.1: Activity-based (bottom-up) calculation of fuel consumption
Source: IMO (2009), Second IMO GHG study

- Establish the types or categories of ships that are relevant to the project and calculate the average ME power;
- Acquire the installed power (*kw*) of each ship category by multiplying the number of ships in each category with the average ME power;
- Establish the categories of shipping routes covered by the project and define the average of ship's servicing speed, distances and the time for cruising, hotelling and hauling in order to calculate the average operating days or hours (*h*);
- Estimate the annual power outtake (*kw h*) by multiplying the installed power with a category-specific estimate of the operating hours of the main engine and the average engine load factor;
- Convert the fuel consumption by multiplying the power outtake with the specific value of fuel oil consumption (SFOC, *g/kw h.*) that is applicable to the engines of the given category;
- Aggregate the total emissions (*t*) for each type of air emissions;
- Present the economic costs (*$*) of GHG emissions by applying the transport costs (*$/t*), if necessary.

The fuel assumption generated by AE or boilers should be calculated by following the same procedures. To complete the calculation, a set of data or statistics with relatively high accuracy are apparently needed, and some relevant assumptions are also duly required. However, the uncertainties do exist due to the estimations of engine workload, ship's speed, and most importantly, the locations of the routes determining the spatial distribution of emissions (Buhaug, 2009; Eyring et al, 2009; Miola & Ciuffo, 2011). The Bottom-up approach is a common and useful method for calculating emissions from shipping activities.

4.2.1.2 A mathematical model: STTEM

To date, some concrete mathematical models have been used in the emissions estimation by those forerunners in the realm of shipping emissions inventory. The Mathematical Model may vary in one form of another, but the derivation and principle of the model remain same. However, one out of those distinguished models was presented by Wang (2010), which is the application of the Ship Traffic, Trade, and Environment Model (STTEM), to estimate the quantity and economic costs of GHG emissions from the perception of the bottom-up approach. For the sake of convenience, a matrix form is used for illustrations.

The principle of STTEM is to demonstrate the relationship between different elements which stand for exclusive information of each process in the approach. For instance, Matrix A can be used to express m types of ships and n routes as categorized in the intend project (Wang, 2010).

$$\mathbf{A}=\begin{bmatrix}\mathbf{a}_{1,1} & \mathbf{a}_{1,2} & \mathbf{a}_{1,3} & \cdots & \mathbf{a}_{1,m}\\ \mathbf{a}_{2,1} & \mathbf{a}_{2,2} & \mathbf{a}_{2,3} & \cdots & \mathbf{a}_{2,m}\\ \mathbf{a}_{3,1} & \mathbf{a}_{3,2} & \mathbf{a}_{3,3} & \cdots & \mathbf{a}_{3,m}\\ \vdots & \vdots & \vdots & \ddots & \vdots\\ \mathbf{a}_{n,1} & \mathbf{a}_{n,2} & \mathbf{a}_{n,3} & \cdots & \mathbf{a}_{n,m}\end{bmatrix}\begin{matrix}(\boldsymbol{m}\ \textbf{types of vessels in route 1})\\(\boldsymbol{m}\ \textbf{types of vessels in route 2})\\(\boldsymbol{m}\ \textbf{types of vessels in route 3})\\(\qquad\qquad\vdots\qquad\qquad)\\(\boldsymbol{m}\ \textbf{types of vessels in route}\ \boldsymbol{n})\end{matrix}\tag{4.2}$$

Fuel consumption calculation is the key process of the whole estimation, which requires many factors to be taken into account. By considering the fact that fuel consumption follows the cubic law of design speed and operational speed, a general formula for ship-based fuel consumption calculation can be written as (Corbett et al, 2009; Wang, 2010):

$$\mathbf{F}=\mathbf{f}\left(\mathbf{d_j},\mathbf{s_k},\mathbf{s_{ok}},\mathbf{M_k},\mathbf{A_k},\mathbf{l_k^m},\mathbf{l_k^a},\mathbf{p_k}\right)\tag{4.3}$$

$$\mathbf{F_{ij}}=\sum_{\mathbf{i,j}}\left[\mathbf{l_i^m}\times\mathbf{MF_i}\times\left(\frac{\mathbf{S_{ij}}}{\mathbf{S_{oij}}}\right)^{\mathbf{3}}+\mathbf{l_i^a}\times\mathbf{AF_i}\right]\times\frac{\mathbf{d_{ij}}}{\mathbf{24}\times\mathbf{s_{ij}}}\times\mathbf{T_{ij}}\tag{4.4}$$

Where *ij* denotes vessel type *i* and a route *j*; *F* is the fuel consumption; *d* is the estimated distance between two selected ports; *k* is the single ship; *s* is the ship's design speed; s_o is the operational speed; *M* is the power of main engine; *A* is the power of the auxiliary engine; l_m is the load factor of main engine; l_a is the load factor of the auxiliary engine; *p* is the specific fuel oil consumption (SFOC); *T* is the total trips made by one ship within a period of time.

If the fuel consumption of each type of ship can be denoted as Matrix B:

$$\mathbf{B}=\begin{matrix}\mathbf{b_1}\\ \mathbf{b_2}\\ \mathbf{b_3}\\ \vdots\\ \mathbf{b_m}\end{matrix}\tag{4.5}$$

Then, the total fuel consumption C in each route is the Matrix multiplication of A and B:

$$\mathbf{C} = \mathbf{A} \times \mathbf{B} = \begin{matrix} \mathbf{c_1} \\ \mathbf{c_2} \\ \mathbf{c_3} \\ \vdots \\ \mathbf{c_n} \end{matrix} \tag{4.6}$$

Thus, c_n will be the total fuel consumption within the period of time.

If the total emissions factor[17] of each GHG (CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs) can be denoted as:

$$\mathbf{D} = (\mathbf{f_1}, \mathbf{f_2}, \mathbf{f_3}, \cdots \mathbf{f_m}) \tag{4.7}$$

The total of each route for each type GHG emissions will be:

$$\mathbf{E} = \mathbf{C} \times \mathbf{D} = \begin{bmatrix} \mathbf{e_{1,1}} & \mathbf{e_{1,2}} & \mathbf{e_{1,3}} & \cdots & \mathbf{e_{1,m}} \\ \mathbf{e_{2,1}} & \mathbf{e_{2,2}} & \mathbf{e_{2,3}} & \cdots & \mathbf{e_{2,m}} \\ \mathbf{e_{3,1}} & \mathbf{e_{3,2}} & \mathbf{e_{3,3}} & \cdots & \mathbf{e_{3,m}} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \mathbf{e_{n,1}} & \mathbf{e_{n,2}} & \mathbf{e_{n,3}} & \cdots & \mathbf{e_{n,m}} \end{bmatrix} \tag{4.8}$$

As illustrated above, the success of estimating the total emissions of each GHG depends on the sources of dataset, parameters of ship engine performance and ship's voyage information of a projected geographical location. However, the ultimate goal of emissions inventory sometimes deserves more convincing stance in assisting policy- and decision-making than presenting the exact figures of emissions.

[17] Emission = Activity (fuel consumption) * Emission Factor

4.2.1.3 Production-based and consumption-based approaches

No matter top-down approach or bottom-up approach, both are carried out by counting the total GHG emissions generated on the designated territory over a given time period, *i.e.*, the location where the emissions are originally and physically produced is the premise in the calculation. Correspondingly, the GHG emissions measurement that focuses on calculating emissions from the actual production place is attributed to the production-based approach, and this approach is the most widely used in the field of GHG emissions inventory. However, some contradictive opinions (Weber et al, 2008; Yan & Yang, 2010) have been raised from other debates which pointed out the shortcomings of the conventional production-based approach. They claimed that irrational emissions allocation showed up in the situation where a country imports carbon intensive materials and exports carbon scarce finished products. For instance, the products such as ipad or iphone, which are heavy carbon consuming in the producing process, are largely made in China, but the end-users are all over the world by just importing the finished products. Till now, they are not even required to pay for the emissions incurred in maritime transport since it is still not binding by the Kyoto Protocol or Post-Kyoto framework. This phenomenon is formally known as "carbon leakage", and this dispute is arguably triggered by China's massive export of embodied carbon to Annex I countries[18], which made up roughly one third of its total carbon footprint in 2005 (Weber et al. 2008; Guan et al. 2009). However, Production-based approach is widely used for measuring CO_2 emissions in IEA (2007_a) and IPCC (2006), since what they believe is that a country should indeed be responsible for the CO_2 emissions within the country.

If it is fair to say that the production-based approach is originated from the "polluter

[18] See appendix B.

pays principle"; in contrast, the consumption-based approach is originated from the "beneficiary pays principle". In recognition of globalization, the consumption-based approach is an alternative method to calculate the emissions from an equity point of view. It means the emissions of products are focused on the region where they are consumed rather than where they are produced. In doing so, exports and imports of a country are two mainstream considerations of calculation. This approach is fairly meaningful for a country where significant difference between exports and imports is inevitable, and China is obviously a typical example in this case. According to a case study presented by Andersen (2010), in terms of maritime transport, China owned a surplus of 39.88 Mt CO_2 emissions by export on the basis of 2008 statistics from China Ministry of Commerce (CMC), which means a large amount of CO_2 emissions has been even generated in the maritime transport only, without mentioning how much emissions would be for producing those huge export products. Therefore, the consumption-based approach is notably effective for preventing "carbon leakage" and also enhancing mitigations for developing countries, especially for those that are specialized in the field of manufacturing (Peters et al, 2008).

4.2.2 Significances of emissions inventory

Having introduced some prevailing approaches of estimating GHG emissions from the maritime transport domain, the purpose is to carry out literature reviews of concurrent methods for maritime emissions inventory and also to scrutinize the concepts and procedures therein. As the different approaches applied, the result of total emissions may, directly or indirectly, be differentiated and possibly leading to a reciprocal way of encountering reluctances from major developing countries and vulnerability for LDCs or LLDCs or SIDSs. As claimed by Lingl et al (2010), some advantages and significances can be summarized from the performance of an emissions inventory, which entails partial decision-making in the progressive process of policy-making. Firstly, the activities that emit the most GHGs can be highlighted by emissions inventory in order to determine the best measures for reductions. Secondly, a benchmark relevant to activities can be established by analyzing the emissions inventory for the purpose of tracking future performance in reducing emissions. Thirdly, as far as potential market and regulatory measures are concerned, the inventory enables an assessment of how it will be affected if a price is imposed on GHG emissions. Last but not least, emissions inventory provides the total amount of emissions that is required in the desire of carbon neutrality[19], and also presents the needs that should be addressed by direct reductions or the purchase of carbon offsets or both.

Currently, China is centered to be the focus point of global controversy for arguing *who* should be responsible for the maritime GHG emissions leaked from imbalance trade and *how much*. Most of the studies and arguments are made from a trade and social responsibility point of view. However, as it is becoming stringent to regulate emissions from maritime transport, an emissions inventory with respect to maritime transport of both export and import is of crucial importance to provide a reference for maritime MBM policy-makers. A relative accurate and reasonable emissions inventory can be worked out if a proper methodology is introduced, and it also carries expectations of compromising maritime emissions allocation in an acceptable manner for participating countries of a MBM regime, especially a country like China. Consequently, the MBM approach will move further forward towards global implementation as proposed orientation, either by an international fund system or a

[19] Carbon Neutrality is a concept that an aspiration of net zero carbon emission is achieved in the way of offsetting the total emission released from activities by buying carbon credits or sequestering equivalent amount from future emission permission. It is applicable to be used in the context of carbon dioxide releasing processes associated with transport sector.

cap-and-trade system.

4.3 Salient Features of the Chinese shipping sector (emission-based)

4.3.1 Global achievement *vs.* Global "debt" in Emissions

The extent of China's impact on the global economy has been widely documented, and China as the rising global power is also inevitable (Gu & Humphrey, 2008). According to the WTO International Trade statistics (2010, p. 5), China overtook Germany and became the leading merchandise exporter in 2009, and meanwhile placed as the second largest importer following the USA, which still remained in the first position. It is also worth noticing that the center of the World Shipping is potentially shifting to the Far East where China is actively playing as the protagonist, *de facto*, as stated in UNCTAD RMT (2010, pp. 30-61), in the same year of 2009, China overtook Germany as the third-largest shipowning country, and it had overtaken both Japan as the second-biggest shipbuilding country and India as the busiest ship-recycling country. In addition, the Chinese shipping sector has covered much more participations in maritime sectors and/or subsectors than ships owning and building/scrapping. Further, other significances are also highlighted on ship registration, classification, crew manning, fleet managing and operation, assets financing, port infrastructure and capacity-building.

Not long ago, the enormous potential demand of Chinese infrastructure constructions and progress of urbanization also impacted and altered the global raw material shipping market with unbelievable emergences of both sky-rocket high and free-fall low BDI, which had never ever been experienced since shipping activities was recorded and charted (see Figure 4.2). According to Stopford (2009, p. 130), between 2002 and 2007 China's steel production grew from 144 million tons a year to 468 million tons a year, adding capacity equivalent to that of Europe, Japan and South Korea. This had created an acute shortage of ships, which also resulted in a congested orderbook of new buildings and rising prices for secondhand ships during that period. Furthermore, maritime education is also said to be another growing indication that China owns the largest number of faculties and students in maritime studies, for example two major maritime universities of Dalian (DMU) and Shanghai (SMU) (2010, pp. 30-61). The scale of seafarers' training in China has been greatly enlarged compared with the figures at the end of 2005, growing from 12,000 to 46,000 every year; the total number of qualified officers has grown from 40,000 to 100,000 (BIMCO, 2010, pp. 7-24). To sum up, being involved in numerous maritime businesses, it is unavoidable to attract global attentions on every move that is likely to take place in the Chinese shipping sector, *ad hoc*, GHG emissions levels in the maritime sector and reduction achievement associated in this sector. After all, China is now leading in some maritime sectors and also trying to lead in others. The issue of GHG emissions reduction will definitely hamper the developing progress of China shipping as it is being expected. However, it is indispensable to curd the GHG emissions by taking all available means from a global social benefit point of view.

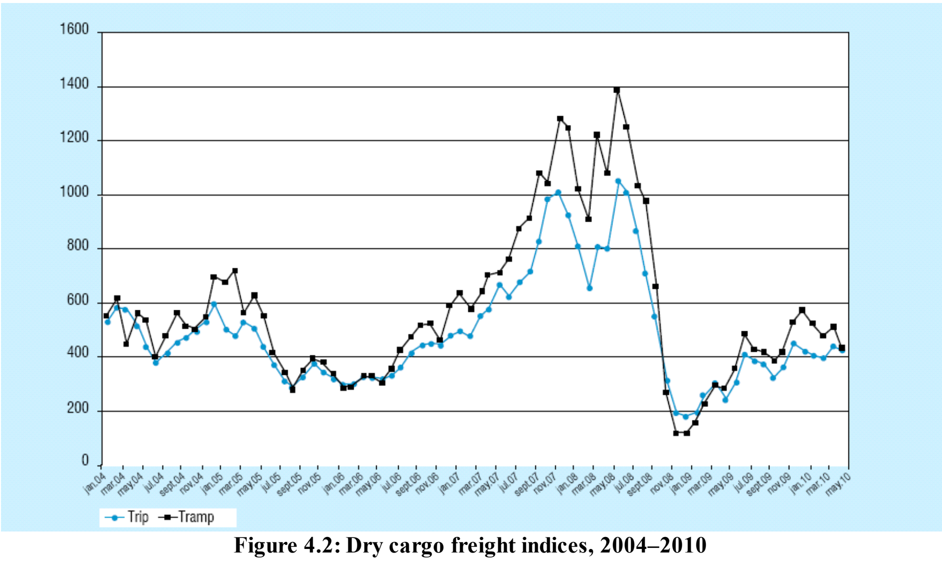


Figure 4.2: Dry cargo freight indices, 2004–2010

Source: UNCTAD RMT (2010, p. 83), based on various issues of Shipping Statistics and Market Review, produced by the Institute of Shipping Economics and Logistics.

As mentioned above, it seems to be no excuse for China to step out of the realm of global maritime GHG emissions reduction. Besides, the IMO has already taken some constructive measures and made firm decisions on the subject matter as per preceding discussions. In the view of maritime transport, the uneven allocation of GHG emissions occurs due to uneven trade volume of export and import. For instance, as Li and Hewitt (2008) pointed out that, the UK claimed 11% achievement in emissions reduction by "exporting" those notorious industries in terms of energy efficiency to China in 2004, whereas China emitted 19% of equivalent emissions by producing the same type and volume of the same products due to much less capacity in energy saving. Consequently, the UK claimed the decline of emissions locally, and China was delighted to improve the regional economy despite of extra emissions. However, the ultimate amount of GHG emissions was actually increased in the atmosphere. Notwithstanding, in terms of emissions, some Annex 1 countries[20] declared their emissions reduction achievement as stated in the Kyoto Protocol by means of shifting production to China to get even cheaper products back. The concealed emissions should be considered as "debt" that is owed by those countries if a levy was imposed on such emissions. Correspondingly, maritime transport will be fed powerfully by the unprecedented growth of trade due to the ongoing process of globalization (Wang & Watson, 2008), but who will be held responsible for the emissions caused by maritime transport for exporting finished products if a MBM is going to take place in the Chinese shipping sector? IPCC (2007, p. 665) defines 'Carbon leakage' as "the increase in CO_2 emissions outside the countries taking domestic mitigation action divided by the reduction in the emissions of these countries". The CO_2 emissions incurred from shipping the products that are shifted to China *does* account for a part of this leakage, which would be in a broader

[20] *Supra,* footnote 15, at p.52.

recognition if it was not free any more. If that is the case, the Chinese shipping sector deserves to get compensations to mitigate the "debt" of maritime emissions from the countries concerned.

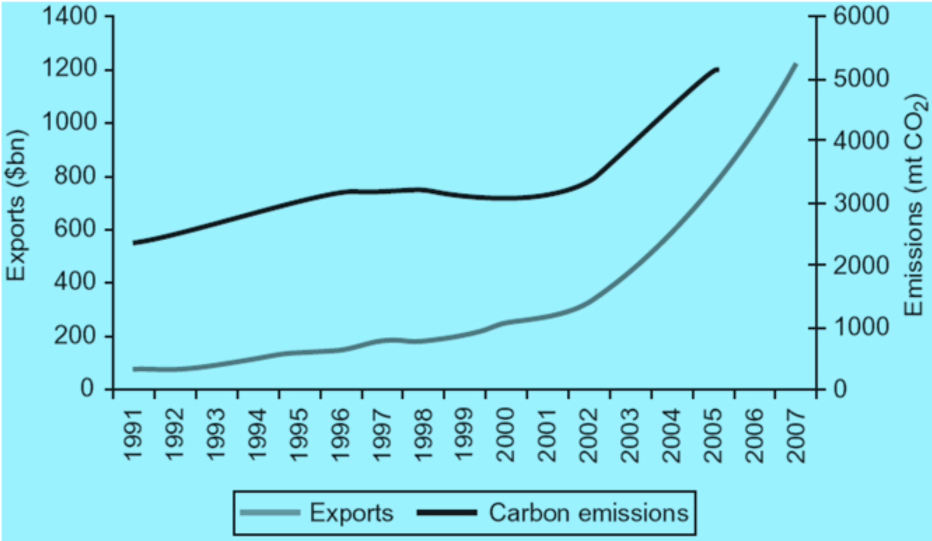


Figure 4.3: Chinese export and CO_2 emission since 1990

Source: Wang & Watson, 2008

4.3.2 National flag vessels *vs*. International flag vessels

According to United Nations Convention on the Law of the Sea (UNCLOS: Article 94), the flag that a vessel is flying has more meaning of administering the vessel than just indicating the vessel's nationality. The developing trend of a country's shipping can also be revealed by analyzing the shipping fleet composition within the country. As UNCTAD RMT (2010, p. 60) stated:

> Developments in China are particularly noteworthy with regard to the supply of, and demand for, shipping services. On the demand side, Chinese containerized exports make up a quarter of the world total. On the supply side, Chinese shipping companies are among the fastest-growing.

During the past decade, both national flag vessels and international flag vessels have increased steadily. The data as shown in Table 4.1 are collected from UNCTAD review of maritime transport from 1997 to 2010 for the purpose of carrying out the following analysis.

Table 4.1: National Flag ships vs. International Flag ships in China (1997-2010)

Year	Number of vessels			Deadweight Tonnage					
	National Flag	International Flag	Total	National Flag	International Flag	Total	Foreign Flag as a % of total	Total as a % of world total	World rank by DWT
1997	1594	378	1972	23162264	13095430	36257694	36.12	5.33	5
1998	1574	432	2006	22147888	15883062	38030950	41.76	5.41	5
1999	1592	472	2064	21978708	16367886	38346594	42.68	5.29	5
2000	1621	551	2172	22316216	17179402	39495618	43.50	5.39	5
2001	1617	599	2216	22340944	18392826	40733770	45.15	5.43	5
2002	1584	652	2236	21673682	20250807	41924489	48.30	5.52	5
2003	1617	704	2321	22680169	21623434	44303603	48.81	5.77	4
2004	1627	788	2415	24206132	23195756	47401888	48.93	6.10	5
2005	1695	917	2612	27110000	29703000	56812000	52.28	6.77	4
2006	1763	1130	2893	29832000	35656000	65488000	54.45	7.22	4
2007	1870	1314	3184	32229000	38162000	70390000	54.21	7.19	4
2008	1900	1403	3303	34351019	50530684	84881703	59.53	8.18	4
2009	1944	1555	3499	37204731	55594490	92799221	59.91	8.40	4
2010	2024	1609	3633	41026075	63426314	104452389	61.00	8.96	3

Source: UNCTAD RMT from 1997-2010, the figures are updated at the beginning of each year (January)
Compiled by the UNCTAD secretariat, on the basis of data supplied by IHS Fairplay
Vessels of less than 1,000 GT are excluded

A fleet composition of a country can be broadly divided into two categories, national flag vessels and international flag vessels. As far as a shipping policy-making is concerned, it tends to be easier for a country to regulate its national flag vessels than the vessels entitling international flags, due to the consideration of jurisdiction of FSC. Since the flag state has primary legal responsibility for the ship in terms of regulating safety, labour laws and on commercial and environmental matters (Stopford, 2009, pp. 663-674), the FSC attendance of proposed MBMs becomes inevitable and approaches rapidly. However, as illustrated in Figure 4.4, China's national flag vessels have grown steadily, albeit at a considerably flat increasing rate, whereas the international flag vessels have increased at a fast growing rate; it has been almost tripled within a decade. A significant increase is noteworthy since the year 2004. Undoubtedly, "Flagging out" is one of the reasons, especially for the ships owned by private shipping companies.

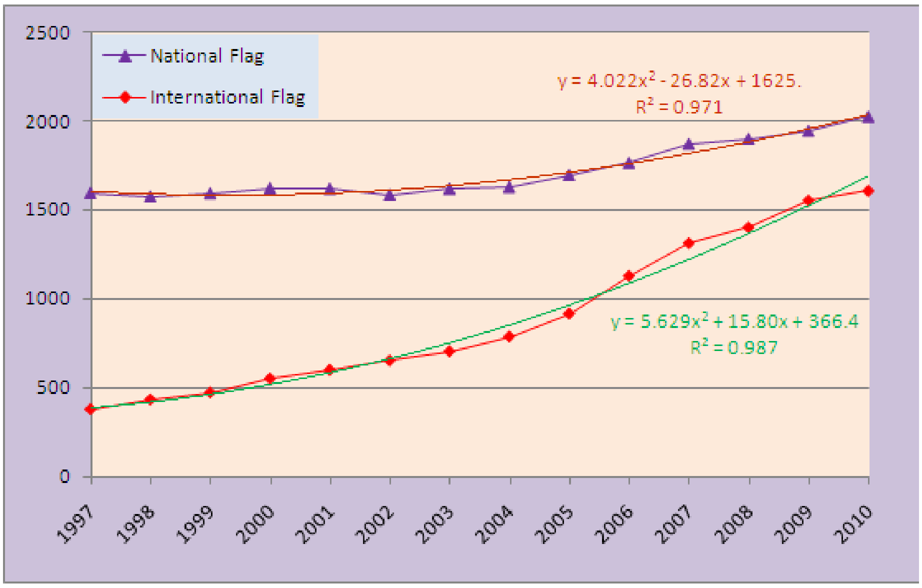


Figure 4.4: Number of Vessels (1997-2010)

Source: UNCTAD RMT from 1997-2010

In addition to "flagging out", the large expansion of international trade attributes to the contribution of increasing international vessels as well. As mentioned earlier, imports and exports of China was subsequently increased due to its open-door policy and thanks to the globalization, which enabled the number of vessels, no matter national flag or international flag, to increase regardless of the "shipping cycles". The data provided from 1997 to 2010 covers at least one and half shipping cycles with two troughs (Stopford, 2009, pp. 104-134), which are included in the last two previous Cycle 21 (1988-2002) and Cycle 22 (2003-2007). Even though vessels were still increasing during recession, it seems to be against the key features of the shipping cycle. The implications relevant to the above are, once again, manifesting how powerful China's economy was/is and the trend that China's shipping will continuously grow. This is still valid even if the forthcoming MBM policy is properly set on track.

According to Figure 4.4, another assumption can be implied by concluding that the number of international flag vessels will surpass the national flag vessels in 2014, simply predicted on the basis of polynomial trend lines of the two figures (see Table 4.2 & Figure 4.4). It is statistically correct to estimate that the lead time for enforcing an IMO convention is approximately *7.3* years on average (IMO MEPC 60/4/8, 2009, p. 14), counting from the time when decisions for developing a new convention are taken until the convention has finally entered into force. The MBM policy-making from shipping would enter into force somehow at least in 2019, if it was hypothetically deemed to be ready in 2012. By then, the international flag vessels in the Chinese shipping sector will be far more than national flag vessels according to the prediction. The point to be taken is the MBM associated in this feature of the Chinese shipping sector should be carried out to emphasize more the role of FSC than national legislation. Moreover, the consistency of MBM policy between national and FSC can prevent more vessels from "flagging out" and also ensure that the shipping emissions are substantively reduced.

Table 4.2: Estimation of Future International flag vessels in China

Year	National Flag vessels	International Flag vessels	Difference
2011	2128	1870	-258
2012	2226	2060	-165
2013	2331	2262	-70
2014	2445	2475	29

Alternatively, some other features of the Chinese shipping fleet composition can be seen from the perspective of deadweight tonnage (DWT). As illustrated in Figure 4.5, the DWT of international flag vessels has grown rapidly and surpassed the DWT of national flag vessels in 2004. However, up to now, there are still more national flag vessels than international flag vessels in terms of vessel's number, which might imply that the size of international flag vessels are much bigger than national flag vessels. Generally, the bigger the ship's size is, the more efficiently the onboard energy is used, primarily due to the *Economics of Scale*. Both state-owned and private shipping companies prefer to engage large and new ships on international voyages to gain competitive edges by economics of scale and to promote safety at sea, particularly for those who are operating containerships. However, it would also be risky to increase excess of emissions if the low slot utilization or broken space is inevitable. Reportedly, most national flag vessels, which are small and obsolete, engage in short domestic voyages. Since the emissions levels related to these small ships are not as optimistic as those of large and new ships, the burden of imposing an MBM on national flag ships are expected to be heavier. Nevertheless, it is not always the case that international flag ships are all large vessels. It is also alleged that hundreds of smaller cargo ships (less than 2000 DWT) are being employed in the transport among ports between Japan, Korea and China.

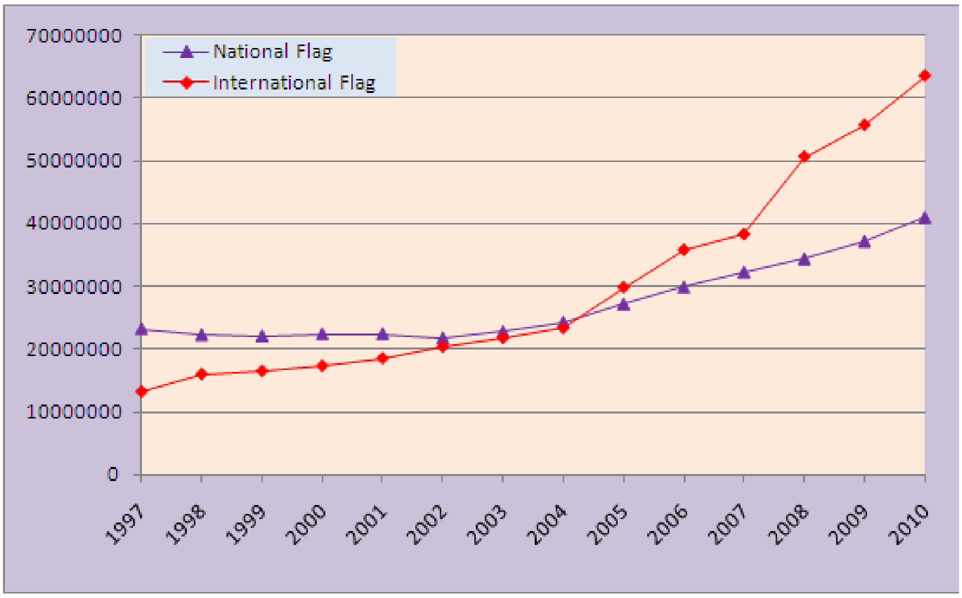


Figure 4.5: Deadweight Tonnage (1997-2010)

Source: UNCTAD RMT from 1997-2010

4.4 Concluding remarks

The process of policy-making is more than just a thought; substantial work needs to be done systematically and reasonably, so does the enforcement of an MBM in the maritime sector. In recognition of social responsibility and economic feasibility, the objective of an MBM policy can be established and the scope of the policy can be outlined. However, the work of maritime emissions inventory should actually be maintained throughout the entire course in order to provide information for three stages: "*Before Implementing*", which is to quantify the objective or task target; "*During Implementing",* which is to monitor the progress on track and rectify the deviations; "*After Implementing*", which is to summarize the ultimate achievement and modify the objective if necessary. The quantified figures are equally important in each stage for ensuring a robust sustainability of the MBM policy. Even though the difficulty is still deemed to exist to obtain exact quantity of emissions, the number is more valuable in illustrating *how far* a country has gone rather than *how much* a country has done.

Unlike the traditional way of describing the Chinese shipping sector, its salient features are discoursed from the emissions point of view, which provides a link to induce the next chapter to come forward with more discussions on the MBM impacts in Chinese shipping sector. China is right now in a good position, politically and economically, to speak for other developing countries and strive for acceptable mitigation. Having introduced the uneven emissions allocation due to the excessive export, the impacts that an MBM could possibly have more concerns about the possibility of frustrating the rebound trade; after all, the economic development to eliminate poverty is still the first priority of China's top decision-making at the present stage.

CHAPTER 5

Impacts of implementing MBM in the Chinese shipping sector

5.1 Introductory remarks

In the preceding chapters, MBM reiterates the emissions reduction objective in the way that simply imposes a price on GHG emissions from shipping sector, *i.e.*, the MBM regime is used to ensure those who emit more, pay more, and *vice versa*. Nevertheless, what happens over here matters over there, which means the *add-on price* may result in some chain reactions with respect to the demand and supply in the Chinese shipping sector. Especially, in view of the projections that world trade would continue to grow, shipping will remain to be the backbone of global economy, *inter alia*, the rise of Chinese Shipping activities. Therefore, this chapter will focus on the global competitiveness of Chinese fleets and predict the impacts of either two market-based measures on the Chinese shipping sector.

5.2 Limitations

The objective of this chapter is to illustrate how the MBM affects the Chinese shipping sector; some limitations are best to be given beforehand in order to focus on the central points that this chapter contributes. The purpose for doing so is to make a rational and convincing study of oncoming impacts.

5.2.1 Types of ships

The types of ships that the Chinese shipping sector includes are miscellaneous, including *conventional ships* like tankers (both dirty-oil ships/VLCC and clean-oil ships/product carrier), bulk carriers, containerships, general cargo ships; the *special ships* like Ro-Ro (PCTC[21])/passenger ships, LPG/LNG, chemical carriers, refrigerated ships and multipurpose vessels; and also some *service ships* like tugboats, supply vessels, dredgers, cable-laying ships, research vessels, training ships (for maritime universities), hydrographic survey ships, and fishing vessels. Obviously, it definitely seems to be cumbersome and meaningless to study the impacts of MBM on all types of ships. Therefore, some limitations have to be drafted accordingly in order to eliminate unnecessary resources for the main objective.

Firstly, the service ships are ruled out from the scope of this study, simply because of the bias "*no fee, no service*". Most of the service ships in China are state-owned except fishing vessels, and those ships are not really capital intensive. They work in the way that if you are happy to have my service, you must be happy to have my price paid as well. Therefore, there will be very few impacts on the service vessels if any MBM is enforced. Fishing boats will neither be scared of MBM, since they can easily transfer the extra price from their emissions to the people who like seafood and tend to be *price inelastic*. Secondly, as regards the special ships, the Ro-Ro/passenger ships will be limited out from the scope. Because the "*cargoes*" that passenger ships handle are human beings with emotions, *i.e.*, they may change the way of travelling as they like, and at some places, it may be the best way to use passenger ships for travelling. The impacts of MBM on passenger ships are mainly reflected on the price of the tickets; some people may accept, whereas some may

[21] PCTC: Pure Car and Truck Carrier

reject and go for other alternatives, so it is hard to make an analysis when the "*cargoes*" are *emotional*. PCTC as ramification of passenger ship gets over the problem and purely carries vehicles rather than passengers, however, there are very few PCTCs owned and operated by Chinese shipping firms, and the trend of being replaced by containership is also intense. Lastly, as for other special ships, such as LPG/LNG and multipurpose vessels and chemical carriers, they are still new to the Chinese shipping sector and not much direct business of owning and operating except that more Chinese seafarers are manned on those foreign ships. Further, the refrigerated ships are almost extinct due to the expansion of reefer containers. To sum up, the scope of this study will be limited to tankers, bulk carriers, container ships and general cargo ships, which are all conventional ships. Further, it also makes sense to carry out an analysis of MBM impacts on the commercial-based shipping sector of China.

5.2.2 Shift of transport mode

As far as the economics of scale is concerned, maritime transport to some extent monopolizes the transoceanic transport market in terms of cargo volume. Therefore, it is fair to say that the extra price incurred from implementing MBM would be, in the long term, passed on to the end-users of the vessel, due to the fact that the alternative means is nearly none in most cases of transoceanic transport.

Yet, someone may still believe partial routes of East-West[22] transoceanic transport can possibly be substituted by the rail transport thanks to the consecutive railway passage, which is called Eurasian continental land bridge. Perhaps, the goods which are required for shorter delivery time, such as perishable or high value cargoes could

[22] The East-West shipping routes include those routes linking the shipping markets of North America, South-east and East Asia and Europe.

use the rail transport by passing through the Eurasian continental land bridge and get transiting time halved[23]. However, as illustrated in the Figure 5.1, the rail transport shows a wide range of CO_2 efficiency[24]. Only very few newly designed locomotives could attain the low efficiency limit as shown in Figure 5.1, the most conventional rail transport is still emitting much more GHG emissions than the maritime transport in terms of ton-mile. It should be borne that the capacity that rail transport provides is very tiny compared to the contemporary giant containerships. There is still hardly any possibility to deploy the non-stopping transport over rail since it would inevitably be subject to some bilateral or multilateral agreements among countries passing by. In addition, the pilferage is another embarrassment in the rail transport. Therefore, the possibility that cargoes will be shifted to rail transport due to the implementation of MBM is not likely to happen.

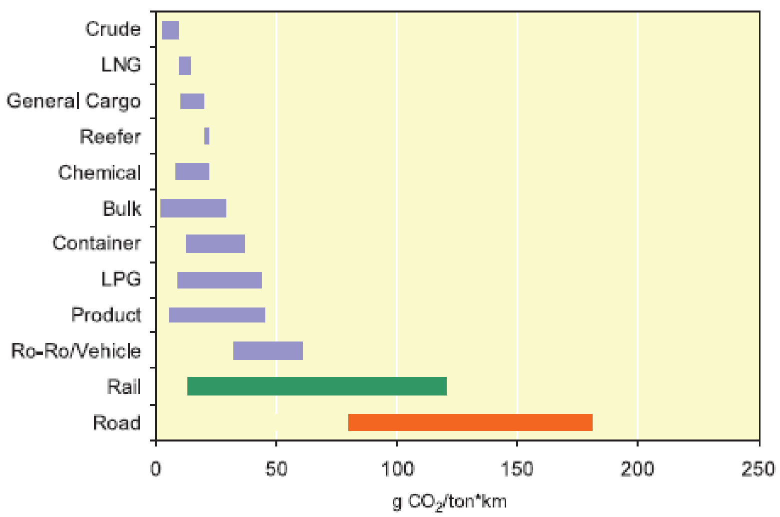


Figure 5.1: Typical ranges of CO_2 efficiencies of ships compared with rail and road transport

Source: Second IMO GHG study, 2009

modes of transport in Figure 5.1. Efficiency is expressed as mass of CO_2 per tonne-kilometre, where the mass of CO2 expresses the total emissions from the activity and "tonne-kilometre" expresses the total transport work that is done. The ranges that have been plotted in the figure show the typical average range for each of them. The figure does not indicate the maximum (or minimum) efficiency that may be observed.

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[23] The Lloyds's List web site gives further information on courses: http://www.lloydslist.com/ll/sector/ports-and-logistics/article31051.ece

[24] CO_2 efficiency can somewhat stand for overall GHG emission level since CO_2 is the largest portion of marine GHG emission.

Similarly, road transport is another issue that leads to the same argument of shifting transport mode. Nevertheless, the cargoes are even more unlikely to be shifted to road than to rail. The same figure tells that the range of road CO_2 efficiency is also wide, but the lower limit is far higher than any types of vessel and rail. Some appropriate regulations will sooner or later be enforced in road transport, which will get the end-users of this transport to pay more for the CO_2 emitted by trailers. Furthermore, some other problems, *e.g.*, highway tolls and traffic jams, also make shippers or cargo owners hesitant to take road transport as an alternative, even if the distance and freight is acceptable. Therefore, it is also easily identified that no cargoes will be shifted to road transport under the impacts of MBM.

5.3 Impacts on Chinese *shipowners*

5.3.1 Scope and methodology

Table 5.1: Key figures of Chinese fleet development up to Mid 2010

Description	Year/Date	Tankers		Bulk carriers		Container ships		General cargo ships		Total		
		No.	DWT (1000)	No.	DWT (1000)	No.	DWT (1000)	No.	DWT (1000)	No.	DWT (1000)	TEU (1000)
Controlled fleet as of January 1st, 2006-2010 and July 1st, 2010; ships of 1000 gt and over	**2006**	367	12937	753	35704	261	6454	1101	8894	2568	64187	583
	2007	402	14317	811	37557	288	7087	1249	9904	2836	69069	657
	2008	492	22718	844	42236	291	7825	1259	10048	2975	83064	723
	2009	539	23547	916	48019	306	8860	1298	10521	3148	91192	812
	2010	547	25319	996	56598	310	9345	1273	10355	3212	101866	860
	Av. Growth rate	**10.5**	**18.3**	**7.2**	**12.2**	**4.4**	**9.7**	**3.7**	**3.9**	**5.8**	**12.2**	**10.2**
	July 1st, 2010	552	26062	1044	59093	328	10104	1288	10830	3295	106307	926
	% share world total	**5.6**	**5.2**	**13.8**	**12.6**	**7**	**5.9**	**9.9**	**10.6**	**8.8**	**8.5**	**6**
Registered fleet as of January 1st, 2006-2010 and July 1st, 2010	**2006**	587	7360	387	14406	151	3615	1021	6345	2326	31936	313
	2007	610	7877	399	15195	158	3855	1018	6313	2364	33440	344
	2008	613	8267	450	17350	164	4094	1022	6274	2428	36211	369
	2009	639	8492	482	19411	174	4564	1022	6201	2495	38889	403
	2010	669	9614	537	22648	189	5106	1003	5982	2578	43585	436
	Av. Growth rate	**3.3**	**6.9**	**8.5**	**12**	**5.8**	**9**	**-0.4**	**-1.5**	**2.6**	**8.1**	**8.6**
	July 1st, 2010	674	10818	588	25142	204	5844	1001	5975	2649	48027	492
	% share world total	**5.3**	**2.1**	**7.4**	**5.4**	**4.3**	**3.4**	**5.7**	**5.6**	**5.6**	**3.8**	**3.2**
Registered fleet by year of build as of July 1st, 2010	2006-2010	132	4352	95	4468	33	1650	47	284	322	10821	136
	Av.age (years)	**21.1**		**19.7**		**15.3**		**28.6**		**23.3**		

Source: ISL based on quarterly updates from HIS Fairplay. (ISL-Institute of Shipping Economics and Logistics)

Perhaps, someone feels too lean to make a study relying on only four types of ships. However, those ships are dominating the Chinese shipping sector in terms of both number and DWT and they are really capital intensive. Not only in China, but also in most maritime nations, it has been witnessed that the majority of domestic and international trading commodities are transported by these four types of ships. The key figures of Chinese fleet development (up to mid 2010) can be seen from Table 5.1, the number and capacity in terms of DWT are indicating a considerable share of the world total. As far as maritime transport is concerned, the seaborne trade cargoes can be divided into three groups, in turn, *liquid bulk* cargoes (crude and products oil), *solid bulk* cargoes (minerals, grains or coals…) and *general* cargoes (containerized and non-containerized cargoes) (Stopford, 2009, pp. 415-467). The four vessel types which are purposely included in the following discussion are respectively undertaking the responsibilities of transporting the three groups of cargoes.

The words *shipowners* as it is referred in the context hereinafter is versatile, as it could be the one who actually possesses and operates the ship; or it sometimes could also be someone who does not possess the ship but operates it as disponent owner (under demise/bare-boat C/P). Nevertheless, the *shipowner* is not the only one player in the shipping market, other attendees, such as cargo owners, charterers, and even brokers, are also making the market tricky and challenging. Therefore, the impacts of MBM is not solely concerned with *shipowner*, but really meant the relationship between *shipowner* and other attendees.

From the overview of seaborne trade, the economic activities create the demand for imports and the supply of exports, not numbers of people, or land, though both have some influence (Stopford, 2009, p. 394). Maritime transport is the genuine link that provides the supply to meet the transport demand derived from imports and exports.

As regards shipping market fluctuations, shipping activities will be naturally ruled under the *law of supply and demand* and the *law of price elasticity*. The two principles are also taken as key economic methodologies in the analysis of MBM impacts on the Chinese shipping sector, since the impacts of MBM from either proposal could also be converted into an extra price in any form of maritime freight or tariff.

5.3.2 Market of Tankers

Table 5.2: Comparison of oil production and consumption in Chinese energy market

Thousand barrels (daily)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Change 2010 over 2009	2010 share of total
Consumption	4766	4859	5262	5771	6738	6944	7437	7817	7937	8201	9057	10.4%	10.6%
Prodction	3252	3306	3346	3401	3481	3637	3705	3737	3809	3800	4071	7.1%	5.2%
Deficit	**-1514**	**-1553**	**-1916**	**-2370**	**-3257**	**-3307**	**-3732**	**-4080**	**-4128**	**-4401**	**-4986**		

Source: BP Statistical Review of World Energy 2011

According to the BP statistical review of world energy (2011): "oil remains the world's leading fuel, at 33.6% of global energy consumption, the consumption growth accelerated in 2010 for all regions; Chinese energy consumption grew by 11.2%, and China surpassed the US as the world's largest energy consumer". It can be seen that oil will continue to dominate in the Chinese energy market in the near future. The IEA World Energy Outlook (2009, pp. 216-218) stated, according to their reference scenarios, the Chinese import of oil would rise significantly in 2030 compared with the figure in 2008. It is also not difficult to prove the IEA prediction by comparing the figures listed in Table 5.2, where the quantities of Chinese oil production and consumption are abstracted from 2000 to 2010 statistics. The symptom of China's *oil-thirsty* is much more easily to be recognized by using the bar graph in Figure 5.2. The oil *deficit* that China is demanding has been increasing at an astonishing rate since 2000. Of course, the amazing economic development of China is the main reason for the driving force of high fuel consumption because constructions and manufacturing need a lot of fuel to complete the works. Furthermore, the number of private cars has increased dramatically within a decade. To have a car is not a luxury any more since people are becoming rich, and the price of a normal car is going down because more foreign car manufacturers start to invest locally. China is a huge and also crowded country due to the largest population in the world; the growing fuel price does not make people frustrated in purchasing cars, and more cars will lead to more traffic jams which will kill more waiting time and consume more fuel. These phenomena are still happening, and the oil demands will be continuously high.

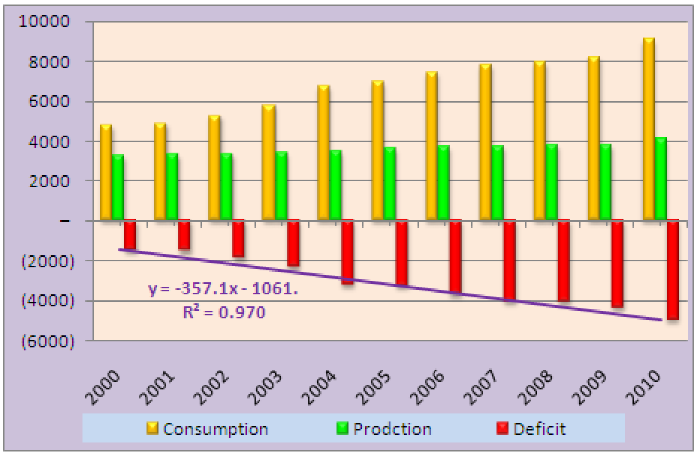

Figure 5.2: Comparison of oil production and consumption in the China energy market
Source: BP Statistical Review of World EnergyJune 2011

In addition, China is not an oil-rich country. The proved oil reserves as shown in Table 5.3 have gone down since 1990, which makes the situation of high demands further severer. The oil refinery techniques and productivity are also not optimal yet, so that is why the production maintains a very slow-motion growth.

Table 5.3: Proved reserves of oil in China

At end 1990 Thousand million barrels	At end 2000 Thousand million barrels	At end 2009 Thousand million barrels	At end 2010 Thousand million tons	At end 2010 Thousand million barrels	Share of total	R/P ratio
16	15.2	14.8	2	14.8	1.10%	9.9

Remark: R/P ratio means Reserves-to-Production Ratio
Source: BP Statistical Review of World Energy 2011

Pursuant to the above, a reasonable assumption can be inferred that the end-users of oil tankers are somewhat *price inelastic* in the Chinese tanker market due to the long-lasting demands, *i.e.*, the end-users of tankers tend to accept whatever additional price is imposed and get the oil that they are highly demanding.

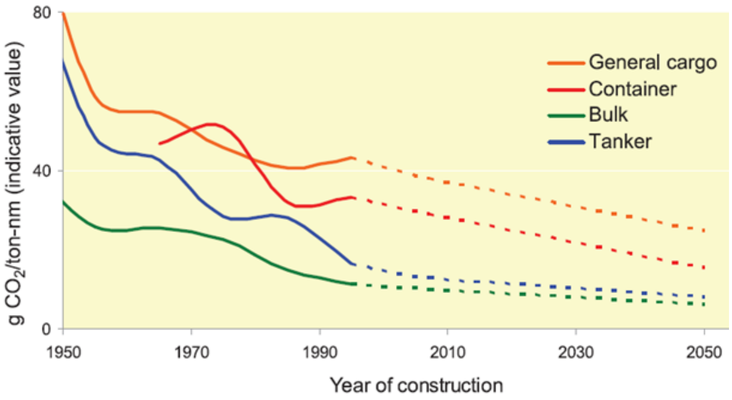

Figure 5.3: Historical improvement in fuel efficiency

Source: Second IMO GHG study 2009

Tankers do not have a leading role in the realm of ship's CO_2 emissions. The vessels' historical emissions level can somehow be reflected by the year of the ship's construction. As indicated in Figure 5.3, tankers have emitted less CO_2 if they were built in recent years. The average age of Chinese controlled tankers is approximately 21.1 years old (ISL Shipping Statistics Yearbook, 2010), so it can rougly be assumed that the average emissions level of Chinese controlled tankers situates somewhere around the 1990 level (*eg, 20 g CO_2/ton-mile*). Comapring with the emissions levels of other types of ships, tankers are relatively competitive in the sector, and the future emissions level for the new builds are predicted to grow at a declining rate. Overall, as far as the MBM impacts are concerned, the tanker *shipowners* could continue to have easy operations on their fleet in the short run.

Notwithstanding, the local high demand (see Table 5.4) gives Chinese tanker *shipowners* more credits to ignore the MBM impacts. However, an excellent tanker *shipowner* who has a longer vision should really focus on the global competitiveness of his/her fleet as the average age of the Chinese controlled tanker fleet is not competitive with other traditional shipping nations (Figure 5.4). If the GHG emissions reduction policy becomes more stringent and the involved parties are more sensitive to the GHG emissions, then the end-users of tankers would be in favour of employing the ships that are newly-built and fitted with efficient technologies. Therefore, from the global market point of view, the consistency of MBM and post-MBM requirements is still necessary for Chinese tankers *shipowners* in the long run to gain global competitiveness.

Table 5.4: Import and export of curde oil from 2000-2009

Year	Crude Oil Import (million tons)	Crude Oil Export (million tons)
2000	70.27	10.31
2001	60.26	7.55
2002	69.41	7.66
2003	91.02	8.13
2004	122.81	5.49
2005	126.82	8.07
2006	145.17	6.34
2007	163.17	3.89
2008	178.88	4.16
2009	203.29	5.07

Source: China customs

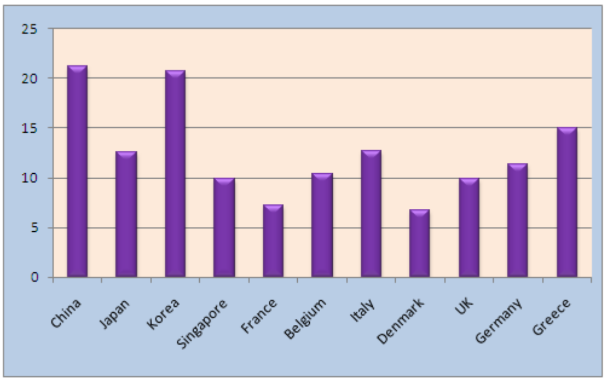

Figure 5.4: Average age of tankers from selected countries

Source: Shipping Statistics Yearbook 2010 (ISL)

Presently, the market share of Chinese controlled tankers is still low compared with the huge oil demands, and majority of market shares are taken by foreign controlled tankers. However, as reported by Leander (2011), Chinese shipping companies have made a large investment in building new and big tankers to meet the domestic oil demands. Therefore, the Chinese tanker fleets is expected to have more newly-built and efficient tankers in the coming years, which will definitely strengthen the competitiveness over other rivals when the MBM is implemented.

5.3.3 Market of Bulk Carriers

Prior to getting into the bulk market, the jargon of "*bulk commodity*" should be distinguished from "*bulk cargo*", where, the "*bulk commodity*" means the commodity like grain, iron ore or coal which is traded in large quantities and has a physical character which makes it easy to handle and transport in bulk; the "*bulk cargo*" means bulk commodities are carried in bulk carriers as differing from the case that the same bulk commodities are sometimes shipped by containers which should be included in "general cargo" (Stopford, 2009, pp. 417-504). The historical bulk trade figures show that iron ore and coal rule the bulk market (Figure 5.5). The influence of grain bulk commodities does not give explicit impacts on the Chinese bulk market, mainly because China is one of the major agriculture countries and also a major food-consuming country. Therefore, it can be assumed that the demand and supply in the grain trade are almost breakeven. However, the trend of containerization is also revealing that some fine grain products in package form are shipped by containers instead of shipped as "*bulk cargo*".

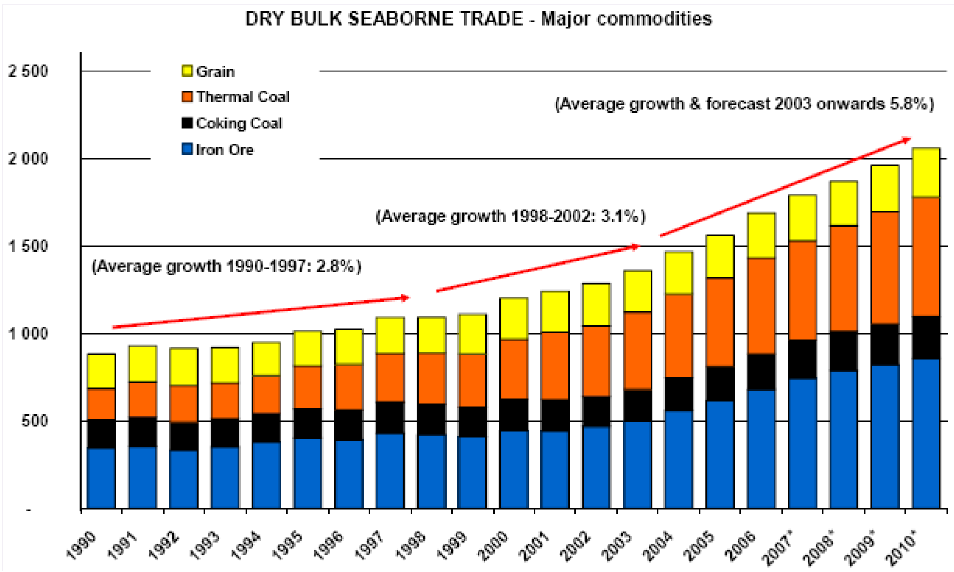

Figure 5.5: Iron ore and coal rule the bulk market

Source: IGC, IISI-Ramco, World Energy Council

Unlike oil reserves, China is rich in coal reserves which have provided a primary energy for Chinese development in the initial stage. Some coal-fired power stations which consume a large portion in the total coal consumption still exist for generating electricity though many new-energy power stations are introduced and entered into service. Fortunately, the production of coal is slightly higher than the consumption thanks to the abundant reserves of coal (see Table 5.5-a & 5.5-b). A surplus (see Figure 5.6) is even slowly increasing after counteracting the consumption, albeit the amount looks tiny. However, a suddenly increased import of thermal and coking coal was recently witnessed in China in 2009. According to the report on China's shipping development (MOT, 2009, p. 3), the import of crude coal was up to 125.8 million tons and increased by *211.9%* compared to 2008, which means a hint that future demand of coal tends to be high as well.

Table 5.5 (a): Comparison of coal production and consumption in Chinese energy market

Million tonnes oil equivalent	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Change 2010 over 2009	2010 share of total
Consumption	737.1	751.9	794.9	936.3	1084.3	1218.7	1343.9	1438.4	1479.3	1556.8	1713.5	10.1%	48.2%
Prodction	762.5	809.5	853.8	1013.4	1174.1	1302.2	1406.4	1501.1	1557.1	1652.1	1800.4	9.0%	48.3%
Surplus	**25.4**	**57.6**	**58.9**	**77.1**	**89.8**	**83.5**	**62.5**	**62.7**	**77.8**	**95.3**	**86.9**		

Table 5.5 (b): Proved reserves of coal in China at end 2010

Million tonnes	Anthracite and bituminous	Sub-bituminous and lignite	Total	Share of Total	R/P ratio
China	62200	52300	114500	0	35

Source: BP Statistical Review of World Energy 2011

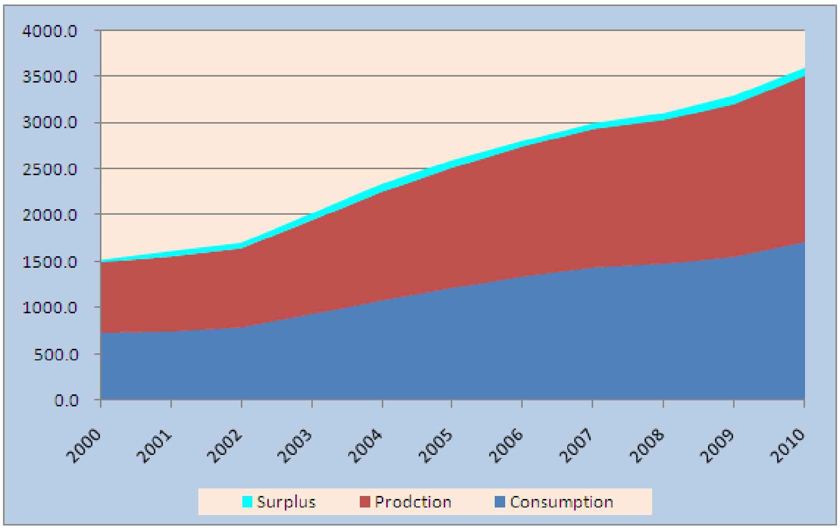

Figure 5.6: Comparison of coal production and consumption in Chinese energy market
Source: BP Statistical Review of World Energy 2011

In view of the market *supply and demand theorem*, the equilibrium point can be deemed to be generally maintained based on the fact that the production and consumption are almost counterbalanced. From a maritime transport point of view, few bulk carriers would be required if the demand of coal is self-sufficient within a nation. However, in recognition of China's vast land territory, some national bulk carriers are engaged in the North-South domestic routes for transporting coals that are mainly exploited in northern coal-mines, from northern ports like QIN HUANG DAO, to southern ports where the industrial areas are centralized. Some bulk carriers which are doing coal cabotage belong to state-owned shipping companies, whereas some smaller ships are private-owned. If the MBM is set on track, the impact is going to take place on the ships that are heavy fuel-consumers, in particular, the private smaller *shipowners*. Because the marginal cost from MBM tends to raise more easily the average costs for small and private *shipowners* than big and state-owned *shipowners*, then the profit is negative if the average cost is higher than the average revenue. In the view of the *price elasticity theorem*, a demand that is *inelastic* in the short run may prove *elastic* when enough time has passed, and a demand tends to be more elastic if close substitute is available (Ma, 2010). Even so, should the end-users consider shifting the mode of transporting coal from bulk carriers to inland rail transport which has already been established for years? A simple cost comparison of transporting 20,000 tons coking coals between the sea and rail transport from the port of QIN HUANG DAO to the port of SHANGHAI is a case in point; the freight of sea transport is around *6.26 $/ton*[25], total freight is approximately *0.125* million (*$*) and transit time is about *54* hours based on the distance of *642* nautical miles at *12* knots[26]; the rail freight is about *13 $/ton*[27], then

[25] The cqcoal web site gives further information on courses: http://www.cqcoal.com/Trade/Price/page/ship_price.jsp?action=2011-09-28

[26] The sea freight exchange web site gives further information on courses: http://www.searates.com/cn/reference/portdistance/?fcity1=714&fcity2=706&speed=12&ccode=2719

[27] The Ministry of railway of the People's republic of China web site gives further information on courses:

the total freight by rail is *0.26* million ($) and haulage time is about *16* hours based on the distance of *1610* km at *100km/h*[28]. According to the above comparison, the sea freight is halved of the rail freight even if the transit time is almost tripled. Sea transport, however, still owns advantages of lower freight and economics of scale when the MBM is enforced. Therefore, it is safe to conclude that the bulk carriers engaged in domestic coal trade will not be threatened by rail transport under the MBM regime.

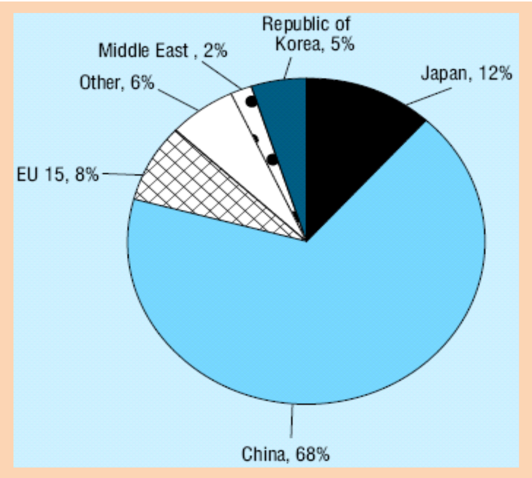

Figure 5.7: World iron ore importers 2009
Source: UNCTAD RMT 2010

The coal trade was just the tip of an iceberg if comparing the coal trade with the iron ore trade in the Chinese shipping market. As illustrated in Figure 5.7, China overwhelmingly headed in the top of global iron ore importers by right of taking up to two thirds (68% in 2009, by 40.1 per cent over 2008) of the world iron ore market. As mentioned earlier, the Chinese demand on iron ore was also the main driving-force for causing sky-rocket high BDI in 2007 and 2008. Although, the worst global recession in over seven decades and the sharpest decline in the volume of global merchandise trade were witnessed in 2009, the world dry bulk trade continued to hold strong, due in particular to China's $586 billion stimulus package and massive infrastructure expenditure in support of domestic demand (UNCTAND, 2010). China remained the world's leading positions of steel consumers and producers in 2009 (Figure 5.8),

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http://www.china-mor.gov.cn/gzfw/yscs/hycs/201012/t20101228_4960.html &
http://www.12306.cn/mormhweb/hyfw/ywzx/hyjlb/jsb/index.html

[28] The distance and speed are assumed on basis of general information from The Ministry of railway of the People's Republic of China.

thanks to the continuously robust growth in China's steel production. China will, nevertheless, continue to power growth in the global iron ore trade. The Chinese demands of iron ore will believably maintain the same positive trend, which can at least be inferred from one significant reason that the housing price is still stubbornly "stay-high" though some measures have been taken on board from a national macro-control policy. Furthermore, according to UNCTAD (2010, pp.21-22) empirical study of the effect of oil prices on maritime freight rates, the elasticity of iron ore is the largest against the other two freights of containers and crude oil respectively, and approximately equal to unity. Based on the aforesaid facts, the total demand would remain unaffected if bunker prices are rising because of MBM. In other words, the implementation of the forthcoming MBM might have the least impacts on the bulk market, especially iron ore market which counts over 50% share of total trade in the bulk market.

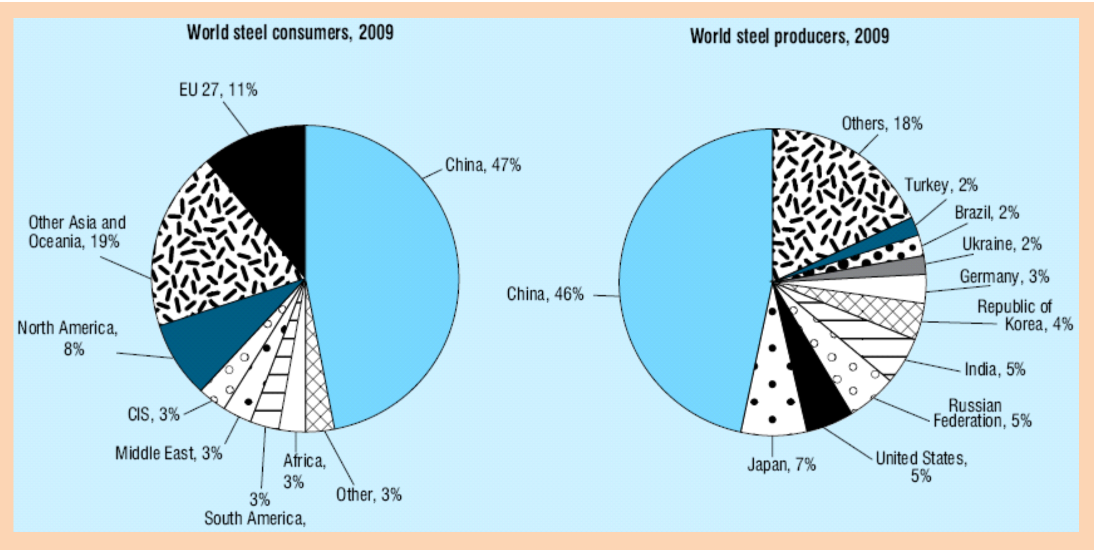

Figure 5.8: World steel consumers and producers in 2009

Source: UNCTAD RMT 2010

Lately, the wiggle room of global competitiveness for Chinese bulk carriers seems to be smaller, because of the trend that Brazilian's Vale[29] attempts to sell iron ore on a

[29] The two biggest iron ore companies are the Brazilian company Vale, and the British/Australian Rio Tinto.

CIF-basis to Chinese receivers with its new ULOC[30] of "*Valemax*" (formerly dubbed "*Chinamax*"). Despite the fact that the Chinese Shipowners Association has pointed out the devastating impact that fleets owned by mining companies will have on the maritime industry's livelihood[31], it can reasonably be estimated that China's state-owned shipping companies will consider building ULOC shortly, since the Chinese central government always insists on the policy that cargoes to and from China should be carried by Chinese shipping firms. Nevertheless, as far as GHG emissions reduction is concerned, this trend will potentially make Chinese bulk carrier owners more confident in facing an MBM.

Although, the average age of Chinese registered bulk carriers is about 19.7 years, the level of CO_2 emissions is, however, the lowest one among the four ship types (Figure 5.3). The features of slow speed and large economics of scale make bulk carriers even more competitive among other types of ships. Nevertheless, according to Figure 5.9, Chinese bulk carriers have disadvantages in age compared to other foreign rivals in the same market. Therefore, the Chinese *shipowners* of bulk carriers have to bear a little bit more MBM price due to middle-aged fuel consumption compared to those who own young-aged bulk carriers.

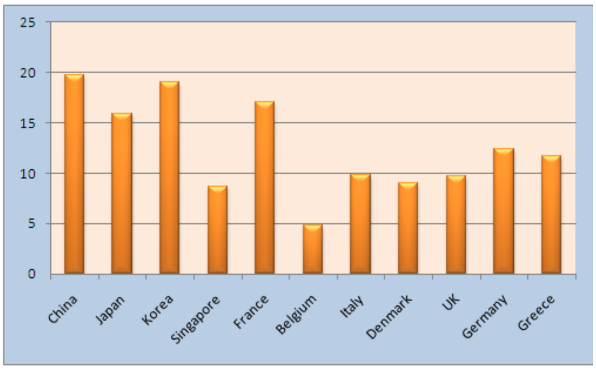

Figure 5.9: Average age of bulk carriers from selected countries
Source: Shipping Statistics Yearbook 2010 (ISL)

[30] ULOC: Ultra Large Ore Carrier, with the capacity of 400,000 dwt.
[31] The Lloyds's List web site gives further information on courses: http://www.lloydslist.com/ll/sector/dry-cargo/article375880.ece.

5.3.4 Market of Containerships

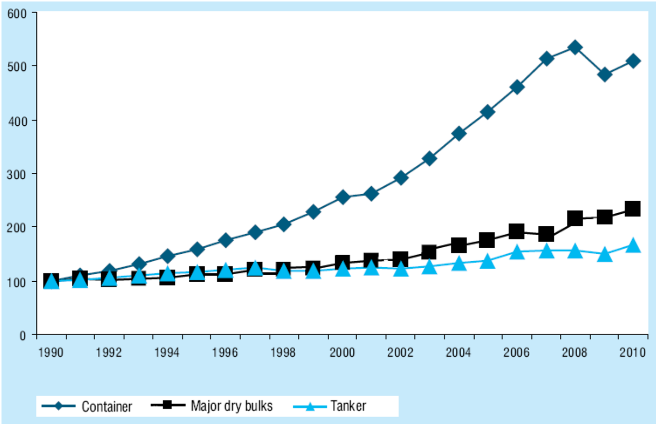

Figure 5.10: Indices for global container, tanker and major dry bulks volumes 1990–2010 (1990=100)

Source: UNCTAD secretariat, based on Review of Maritime Transport, various issues; and on Clarkson Research Services, Shipping Review and Outlook, spring 2010.

Contemporarily, the massive manufactured goods are transported by containerships which are mainly operated on liner basis. The features of container shipping operations, such as quick cargo handling, door-to-door service and fixed sailing schedules, enable the *shipowners* of containerships to be superior to other types of ship. As illustrated Figure 5.10, the container cargoes have already been far ahead of bulk and oil cargoes in terms of volume. However, the year 2009 was proved to be the most challenging and dramatic year in the history of container shipping due to the global financial crisis and subsequent economic recession; thus, the container trade recorded its first absolute contraction ever since containerization began (UNCTAD, 2010, pp. 17-20). The crisis also negatively impacted the Chinese container fleet at the beginning of the year 2009, and some concrete measures, such as slow-steaming, postpone delivery of new builds, and seal of capacity, had been adequately taken by major national fleets in order to withstand the tough time. However, the dilemma had been promptly changed and improved due to the Chinese government stimulus package at the end of 2009. Therefore, the perspective container market is still looking good in the coming years.

The national containership fleets are the mainstays in competing with other major foreign liner companies. The typical tycoons are COSCON (COSCO container lines) and CSCL (China Shipping Container Lines). Based on the latest survey from Alphaliner and American Shipper, COSCON ranks No.4 among the top 20 container lines and of which CSCL ranks No.8. Even though the COSCON showed the highest growth rate over the past year and moved 3 ranks ahead (see Table 5.6), the total TEU only approximately counts for one fourth of No.1 carrier, one third of No.2 and half of No.3, whereas CSCL takes an even smaller proportion. As far as the market share is concerned, the Chinese controlled fleets are less competitive with those powerful liner companies. Further, Maersk Line recently launched a new program which is called "Daily Maersk[32]" to introduce absolute reliability and reduce transport time. This action will definitely make the burden of grabbing market shares heavier for Chinese owners of containerships.

Table 5.6: Top 20 container lines (Ranked by operating capacity, in TEUs, as of August, 2011)

Pos. ('10)	Carrier/group	Country	TEUs Aug '11	TEUs Aug '10	% change	No. of owned ships (TEUs)	No. of charter ships (TEUs)	Orderbook (TEUs)
1 (1)	A.P. Moller - Maersk Group	Denmark	2,458,345	2,097,501	17.2%	213 (1,153,543)	432 (1,304,802)	51 (521,033)
2 (2)	Mediterranean Shipping Co.	Switzerland	2,032,881	1,728,585	17.6%	212 (1,007,360)	262 (1,025,521)	45 (476,796)
3 (3)	CMA CGM Group	France	1,294,053	1,140,825	13.4%	95 (506,799)	294 (787,254)	16 (144,334)
4 (7)	COSCO Container Lines	China	652,400	530,859	22.9%	97 (349,987)	52 (302,713)	32 (244,168)
5 (4)	Hapag-Lloyd	Germany	630,281	603,439	4.4%	56 (267,259)	89 (363,022)	10 (131,000)
6 (6)	Evergreen Line	Taiwan	611,678	596,627	2.5%	88 (330,167)	79 (281,511)	35 (308,000)
7 (5)	APL	Singapore	580,595	598,134	(2.9%)	45 (169,547)	99 (411,048)	29 (300,880)
8 (9)	China Shipping Container Lines	China	505,106	486,871	3.7%	76 (315,864)	66 (189,242)	12 (93,896)
9 (8)	CSAV group	Chile	493,506	528,171	(6.6%)	10 (45,632)	111 (447,874)	12 (98,589)
10 (10)	Hanjin Shipping group	South Korea	493,221	462,846	6.6%	38 (227,550)	65 (265,671)	32 (248,963)
11 (11)	MOL	Japan	417,897	386,308	8.2%	35 (210,338)	65 (207,559)	13 (120,830)
12 (14)	OOCL	Hong Kong	412,182	349,180	18.0%	46 (281,432)	41 (130,750)	12 (131,928)
13 (13)	Hambürg Sud group	Germany	409,625	358,709	14.2%	46 (195,086)	74 (214,539)	32 (203,958)
14 (12)	NYK Line	Japan	397,473	373,607	6.4%	57 (299,163)	44 (98,310)	6 (61,476)
15 (15)	"K" Line	Japan	342,763	322,707	6.2%	40 (226,050)	40 (116,713)	5 (45,200)
16 (16)	Yang Ming Line	Taiwan	334,768	315,798	6.0%	47 (200,377)	34 (134,391)	15 (95,626)
17 (17)	Zim group	Israel	333,697	310,694	7.4%	34 (158,129)	65 (175,568)	13 (153,216)
18 (18)	Hyundai Merchant Marine	South Korea	316,108	282,272	12.0%	17 (100,646)	48 (215,462)	15 (156,075)
19 (19)	Pacific International Lines	Singapore	267,774	250,284	7.0%	93 (161,819)	47 (105,955)	20 (65,400)
20 (20)	UASC	Kuwait	234,815	207,806	13.0%	28 (126,696)	28 (108,119)	8 (104,800)
Total of top 20 carriers			13,219,168	11,931,223	10.8%			413 (3,706,168)
Average of top 20 carriers			660,958	596,561				20.7 (185,308)

Notes: A.P. Moller - Maersk Group: Maersk Line, Safmarine Container Lines, MCC Transport.
CMA CGM Group: CMA CGM, ANL, MacAndrews, Delmas, OTAL, Comanav, CNC Line, U.S. Lines.
CSAV group: CSAV, CSAV Norasia, Libra.
Evergreen Line: Evergreen Group in May 2007 adopted unified trade name of Evergreen Line, combining Evergreen Marine Corp. (Taiwan) Ltd., Hatsu Marine (now Evergreen Marine (UK) Ltd.), Italia Marittima SpA and Evergreen Marine (Hong Kong) Ltd.
Hambürg Sud group: Hambürg Sud, Alianca, Costa Container Lines.
Zim group: Zim, Gold Star Line, Laurel Navigation.

Sources: Alphaliner & American Shipper

[32] The Maersk line web site gives further information on courses: http://www.dailymaersk.com/

In light of global competitiveness, the impacts of MBM on the Chinese liner fleets tend to be heavier than other types of ships, simply because the shippers are quite likely *price elastic* due to substantive substitutes in the transport market. The competition is tough, as many liner operators concentrate their core business in China, which is regarded as the world manufacturing base. Moreover, some liner operators also invest in container terminals and act as PTOs[33] to have dedicated berths for the purpose of saving turnaround time and getting more containers transported or transshipped. Another significant trend is: the No.1 liner firm Maersk line moves even more forward by investing in the "*Malaccamax*" containership with a capacity of 18,000 TEU, and now Maersk Line is not alone in the new generation of super-sized boxships since another containership owner Seaspan[34] declared that they would soon place orders of 18,000 TEU containerships. The new generation of super-sized containerships is called triple-E and claiming environment-friendly operations, *e.g.*, new designed hull, economics of scale and less GHG emissions. However, the slot utilization is of utmost importance for achieving green operations of those giant boxships, otherwise they will turn into heavy polluters. Nevertheless, the big player in the liner field has never stopped attempting to monopolize the transport of containerized cargoes by investing in huge and efficient boxships. The negotiations on who should be responsible for the extra MBM price will be very tough, especially when the shipowner is in a favourable position in the market. Subsequently, Chinese liner fleets will have to face the dilemma during the time when the MBM is included in the container market if the market share is reducing.

[33] PTO: Port and Terminal Operator.
[34] The Lloyds's List web site gives further information on courses: http://www.lloydslist.com/ll/sector/containers/article380339.ece.

5.3.5 Market of general cargo ships

Foremost, the general cargoes are normally divided into *containerized* cargoes and *non-containerized* cargoes. Apparently, the general cargoes in the following context are exclusive for *non-containerized* cargoes. Anyhow, the general cargo ships are even more dismal comparing the containerships, since more commodities are stuffed into containers and transported by containerships. An upcoming trend can be foreseen that smaller containerships may intrude the traditional business that general cargo ships normally handle. The attempts have even been tried on transporting coals by containers, if that is possibly done, what else cannot be containerized? From a long term point of view, the market of general cargoes is diminishing due to the fast growth of containerization, which also means the demand of the general cargo market is going to be weakened. Therefore, the end-users of general cargo ships will subsequently become *price elastic* due to the availability of substitutes from boxships and excessive supply in the transport market. Furthermore, by taking a look at Figure 5.3, the CO_2 emissions level of general cargo ship is the highest among the four types of ships, and the average age of 28.6 (ISL, 2010, p. 240) years makes the emissions efficiency of general cargo ships even worse. If more market shares are potentially in the hands of boxships which are handy and more fuel inefficient, under such conditions, the competition in the subsector of general cargo ships is going to be fierce, *i.e.*, those that can perform efficiently will gain the competitive edge and market shares over the ones that cannot be efficiently operated. Consequently, the aged and inefficient ships will be phased out from the market and sent to be demolished to reduce excess capacity of supply. In addition to the domestic trade, the majority of general cargo ships are engaged in foreign trade within the Asian region only. Many *shipowners* experienced terrible port congestion in some major Chinese ports of handling general cargo, for instance, in the port of Tianjin, it was reported that hundreds of general cargo ships were waiting for berths at anchorage when the market was prosperous. Despite the fact that *Shipowners* may gain or lose earnings depending on how the demurrage/despatch clauses are agreed in C/P, the efficiency of operating general cargo ships is not optimal from a GHG emissions reduction point of view. Overall, general cargo ships are considerably old (see Figure 5.11) and largely consist of secondhand ships, MBM impacts on those *shipowners* are inevitable and vulnerable, and the ships that are inefficient and aged may end service as soon as the fixing operating cost is by no means to be offset.

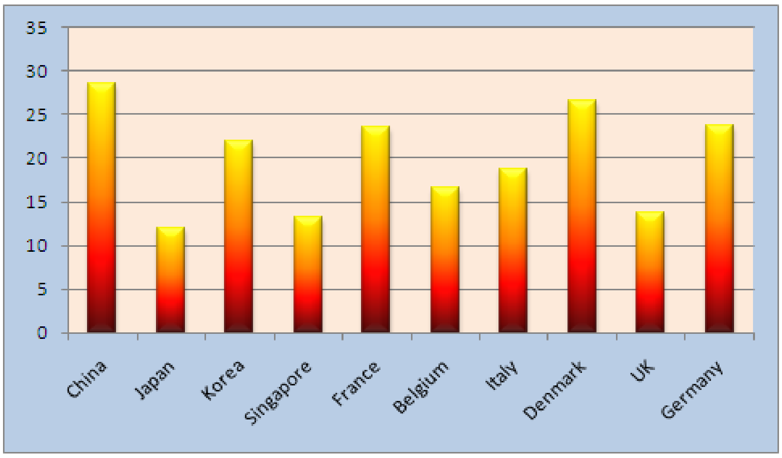

Figure 5.11: Average age of general cargo ships from selected countries
Source: Shipping Statistics Yearbook 2010 (ISL)

5.4 Impacts on affiliations

A slight move in one part may affect the situation as a whole, since the role of *shipowner* is one of the most important parts of the entire supply chain covered by the shipping sector, other affiliations are therefore subject to direct or indirect impacts due to the implementation of MBM as well. Firstly, the shipyards will have to enhance their capabilities of designing and constructing all types of ships efficiently in order to get more orders, with especial respect to EEDI requirements. In addition, the green operations have also been drawn into ship repairing and recycling industries. Secondly, the port authority will have to improve the services they provide to avoid port congestion, by both increasing the berth utilization and smoothing port logistics. Some other new services in terms of efficiency, for instance, the shore power supply facilities, should also be taken into consideration for future port developments. As regards the bunker suppliers, which are mainly stated-owned in China, nothing will be in particular changed unless in the case of International fund where the bunker levies need to be collected, then some administrative arrangements would be established accordingly. Last but not least, functions of PSC & FSC will be expanded with respect to the robustness of MBM, especially for FSC due to “Flagging out”. As indicated in Figure 5.12, Panama flag is the biggest open registry among the top 10 open registries[35] for Chinese owned ships. Therefore, Chinese PSC should maintain good cooperation, primarily with the Panamanian FSC, to carry out fair, free-fraudulence and effective surveillances over the respective responsible areas. The impacts of some relevant affiliations is more or less touched upon due to their close relationship with *shipowners*, which are used to illustrate shipping is dynamic and subject to chain reactions.

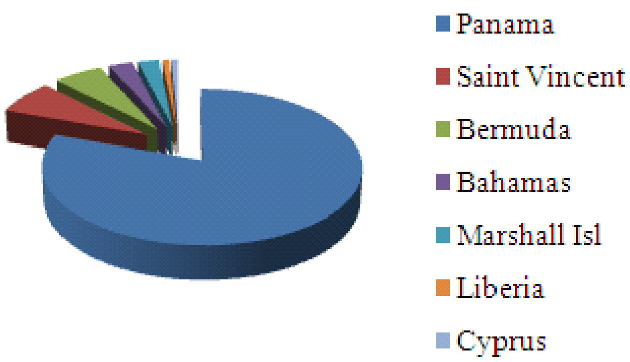

Figure 5.12: The percentage of Chinese registered ships in top 10 open registry
Source: Source: Shipping Statistics Yearbook 2010

[35] Top ten open registries are: Panama, Liberia, Marshall Islands, Bahamas, Malta, Cyprus, Antigua % Barbuda, Bermuda, Saint, and Cayman Islands. (ISL, Shipping Statistics Yearbook, 2010)

5.5 Concluding remarks

Undoubtedly, China is a major shipping nation, but is not a powerful shipping nation yet. The development of Chinese shipping activities has failed to keep pace with the fast growth of the trade. Further, the low market share will cause Chinese *shipowners* to be more cautious about the impacts from MBM implementation. From both long-term and short-term points of view, the owners of tankers and bulk carriers may suffer least impacts due to high demands. The existing fleets of tankers and bulk carriers are expecting to have more newly-built ships to replace aged ships and meet the high national demands as well. Therefore, in the tanker and bulk market, Chinese controlled fleets may have potential advantage over foreign fleets under the MBM regime by the time when new ships are in, either by saving bunker levies in the international funds system or selling emissions credits in the emissions trading system. In contrast, the owners of containerships will encounter a great pressure of being green due to fierce competition. Till now, the Chinese controlled containerships are still less than foreign controlled fleets no matter in the number of vessels or the capacity of DWT. Lastly, the owners of general cargo ships will require some more strategic plans to fight against both the impacts from MBM and the threats of containerization.

CHAPTER 6

SUMMARY and CONCLUSIONS

The approach of controlling marine GHG emissions by means of MBM is still in the conceived stage and not so attractive to all maritime nations, especially in the developing world (IMO, 2011). However, the speed of implementing an MBM is urgently driven by some powerful maritime nations in the developed world. Truthfully, it is indeed urgent when adverse effects are being uncovered day-by-day with respect to global climate changes.

The EEDI and SEEMP, which are respectively based on technical and operational supports, are attributed to *direct* approach for regulating GHG emissions from shipping sector, then, the implementation of MBM is an *indirect* approach which provides nil solutions but incentives or penalties and leaves the participants to achieve energy efficiency on their own. However, in the face of GHG emissions reduction, it is not how the way approaches that matters, it is what accomplishment finally shows. Furthermore, it is by no means possible that the state-of-the-art technologies and operations can be applied to all ships, due to the fact that the different fleet economic statuses and managing philosophies are unavoidable in the real world. Therefore, the MBM will be appropriately introduced where it can be believed to complement regulatory defaults in the overall objective of emissions reduction.

In this dissertation, in addition to the briefings of international environmental framework, the central core is addressed by attempts of illustrating how the economics works for MBM and what impacts are about to happen in the Chinese shipping sector. The economic concepts and instrument cannot be detached from environmental policy-making, *inter alia,* the MBM policy-making, since the economy and environment are closely correlated. To this end, the chapters are purposely compiled by following a logic sequence, where the rationales of two prevailing MBM proposals are presented for the purpose of pointing out the main topic; then the concept of MBM is theoretically proven to be feasible by using economic explanations; the argument on methods of emissions inventory is also highlighted to avoid uneven emissions allocation from a practical point of view. Finally, the impacts on the Chinese shipping sector are emphasized by analyzing the future trends of demand and supply in the Chinese maritime transport market.

In essence, the shipping is naturally regulated by the *law of demand and supply*, which can be helpful to make a reasonable analysis of the MBM impacts. Shipping is also subject to having "broken weather", *i.e.,* the fluctuation inevitably existed in the eye of shipping cycles. As far as the CBA method is concerned, it will be easier to examine and analyze the impacts of MBM policy-making by giving a price which could be possibly done by using the environmental economic concepts and methodologies. Furthermore, this research will not be convincing and workable without the statistical dataset which reflects past trade performance and the estimation of future Chinese shipping developments by understanding the actual situations per se. In the end, the *law of price elasticity* can best describe how the end-users of ships respond in reaction to the forthcoming MBM.

By far, the parties involved have probably been aware that the globalization of trade has numerous environmental implications and creates a mechanism for consumers to shift environmental pollution associated with their consumption to other countries (Yan & Yang, 2010). Due to the phenomenon of "carbon leakage", China is attributed to be the largest emissions nation by surpassing the USA. Therefore, the China has been pushed ahead in the world emissions reduction campaign by attracting global attentions to concerning how much emissions can be reduced in all respects. Nevertheless, the intense measures for controlling CO_2 emissions have been widely deployed under China's recent national 12^{th} Five-Year plan, and the CO_2 emissions are hoped to be curbed as time goes along. Even though the detailed and concrete plan regarding the Chinese shipping sector are not applicable so far, some preliminary studies have already been carried out and hopefully will be included in the national legislation shortly.

Regardless of the non-commercial market, the MBM impacts on the Chinese shipping sector are exclusively concluded as per four major ship's markets, *i.e.*, tankers, bulk carriers, containerships, and general cargo ships. Generally, the former two seem to be relaxed in the short run, whereas, the latter two might have already felt the aggressive challenges from other rivals in chasing who is the most *green*. However, in the view of historical responsibility, efforts should be made so that the "common but differentiated responsibility" principle is also made applicable in the international shipping sector because it will not only allow mitigation for developing countries, but also attract developing countries to take part in the MBM regime. After all, to reduce GHG emissions from the international shipping sector, it should be carried out in a way that fairness is maintained to assure a level of participation of developing countries in international shipping from declining.

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APPENDIX: A

Table (1): Summaries of 10 MBM proposals

No.	Title	Sponsor	Focus points of the proposal	Source
1	International Fund	Cyprus Denmark Marshall Islands Nigeria International Parcel Tankers Association (IPTA)	• Establish a global reduction target; • Purchase credits when emissions above target; • A mandatory registration for bunker fuel suppliers; • Maintain a global ship-specific registry; • Contributions collected per ton bunker fuel; • Subsequent adjustment made every four years or agreed interval; • GHG contributions used for mitigation and adaption purpose in developing countries; • Only Parties to the new convention eligible to receive the revenues;	MEPC 60/4/8
2	Leveraged Incentive Scheme (LIS)	Japan	• Rationale same as international fund; • The concept of LIS: a part of GHG contributions is refunded to " good performance ships"	MEPC 60/4/37
3	Port State Levy (PSL)	Jamaica	• Utilizing the ship traffic, energy and environment model (STEEM); • Levy charged on ships calling respective ports based on the amount of fuel consumed by the	MEPC 60/4/40

			respective ship on its voyage to that port; • Regardless ship's design, operations or energy source;	
4	Ship Efficiency and Credit Trading (SECT)	United States	• Purposely designed to focus on emissions reduction activities in shipping sector; • All ships are subject to mandatory energy efficiency standard; • Establish an efficiency-credit trading programme; • The stringency level of efficiency standards based on efficiency technology and methods; • Standards become more stringent over the time; • Achieve relative emissions reduction, i.e., reductions in emissions per ton mile and not set an overall target for the sector;	MEPC 60/4/12
5	Vessel Efficiency System (VES)	World Shipping Council	• Ship judged against a requirement to improve its efficiency by x% below the average efficiency; • Cover both new builds and existing ships; • New builds must meet the specified standards or they may not operate; • Existing ships failing to meet the required standards have to pay the fee applied to each tone of fuel consumed; • Standards become more stringent over the time; • A more efficient ship would pay a small penalty than a less efficient ship that falls short of the	MEPC 60/4/39

			standards by a wide margin;	
6	Emissions Trading System (ETS)	Norway	• Set a sector-wide cap on net emissions from international shipping; • Establish a trading mechanism, both in-sector and out-sector; • Use of out-sector credits allows for further growth of the shipping sector beyond the cap; • Auction revenue provides for mitigation and adaption within maritime sector; • Ships require to surrender one credit for each ton of CO_2 emitted; • ETS covers all types of ships engaged in international trade above a certain size threshold;	MEPC 60/4/22
7	Emissions Trading System (ETS)	United Kingdom	• Similar as ETS proposed by Norway; • Methods of allocating allowance are different; • Allowance could be allocated to national governments for auctioning; • Net emissions cap would be set with long term declining trajectory with discrete phases;	MEPC 60/4/26
8	Emissions Trading System (ETS)	France	• similar to the Norwegian proposal for an international ETS;	MEPC 60/4/41
9	A penalty on trade and development	Bahamas	• no explicit standards or reductions to be achieved in-sector or out-sector; • set forth that the imposition of any costs should be proportionate	MEPC 60/4/10

			to the contribution by international shipping to global CO_2 emissions;	
10	Rebate Mechanism (RM)	International Union for Conservation of Nature (IUCN)	• Rebate Mechanism to compensate developing countries for the financial impact of a MBM; • A developing country's rebate would be calculated on the basis of their share of global costs of the MBM, using readily available data on a developing country's share of global imports by value as a proxy for that share; • Rebate Mechanism could be applied to any maritime MBM which generates revenue such as a levy or an ETS;	MEPC 60/4/55

As agreed, a MBM must meet all the nine fundamental IMO principles for future regulation on GHG emissions from International Shipping. The nine principles are summarized in the below table:

Table (2): IMO NINE Fundamental principles for regulating GHG emissions

- effective in contributing to the reduction of total global greenhouse gas emissions;
- binding and equally applicable to all flag States in order to avoid evasion;
- cost-effective;
- able to limit, or at least, effectively minimize competitive distortion;
- based on sustainable environmental development without penalizing global trade and growth;
- based on a goal-based approach and not prescribe specific methods;
- supportive of promoting and facilitating technical innovation and R&D in the entire shipping sector;
- accommodating to leading technologies in the field of energy efficiency;
- practical, transparent, fraud free and easy to administer.

APPENDIX: B

Annex 1 countries (Kyoto Protocol)			
1	Australia	**22**	Liechtenstein**
2	Austria	**23**	Lithuania*
3	Belarus*	**24**	Luxembourg
4	Belgium	**25**	Monaco**
5	Bulgaria*	**26**	Netherlands
6	Canada	**27**	New Zealand
7	Croatia*/**	**28**	Norway
8	Czech Republic*/**	**29**	Poland*
9	Denmark	**30**	Portugal
10	European Economic Community	**31**	Romania*
11	Estonia*	**32**	Russian Federation*
12	Finland	**33**	Slovakia*/**
13	France	**34**	Slovenia*/**
14	Germany	**35**	Spain
15	Greece	**36**	Sweden
16	Hungary*	**37**	Switzerland
17	Iceland	**38**	Turkey
18	Ireland	**39**	Ukraine*
19	Italy	**40**	United Kingdom of Great Britain and Northern Ireland
20	Japan		
21	Latvia*	**41**	United States of America
***Countries that are undergoing the process of transition to a market economy.**			
**** Publisher's note: Countries added to Annex I by an amendment that entered into force on 13 August 1998, pursuant to decision 4/CP.3 adopted at COP 3.**			
**** Publisher's note: Countries added to Annex I by an amendment that entered into force on 13 August 1998, pursuant to decision 4/CP.3 adopted at COP 3.**			