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TOWARDS A MORE SUSTAINABLE WORLD: The example of Shipbuilding in North-East Asia

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Shipping is mostly an unknown and unrecognised economic activity. However, it is responsible for 90% of the world trade. This impressive number should be a reason for us to highlight the place of this indispensable business tool in the world we live in. Performed by many companies called ship-owners, the activity of shipping was said to be using 50,420 merchant ships on January 1st 2016[1], ranging from the smallest cargo carriers to the largest container carriers. Needless to say that such an industry needs a powerful and competitive supply offered by well-implanted companies in order to survive. With no other way to be as effective and cheap in the amount of merchandise transported by trip, shipping is here to stay, as well as shipbuilding, which is the compulsory corollary of the former.

Today, container ships can be as long as 400m (the equivalent of 4 football pitches), are powered by enough energy to light up a city of 16000 inhabitants, and can transport the equivalent of 200,000 to 210,000 tons of cargo, shortening the distance and with the less impact on the environment (by ton transported). Indeed, transporting a container from Shenzhen to Rotterdam costs $1082, or just 50 cents per kilo, in just 30 days. Moreover, a 9500 TEU containership only uses 8,3 CO2 grams per ton/kilometre, whereas a cargo plane needs 570 CO2 grams per ton/kilometre, and lorry would use 104,5 CO2 grams per ton/kilometre[2]. Needless to say that shipping is the shortest, the cheapest and the eco-friendliest way of transporting merchandises.

However, as shipping represents 90% of world trade, it is safe to assume that it still pollutes a lot. Shipping carbon dioxide emissions were equal to 5% of human global emissions in 2015, and world trade is expected to double from now to 2050[3]. If you added shipping to the list of the world's most polluting countries, it would come in sixth place. Pollution from shipping includes: ballast water, sound pollution, wildlife collisions, atmospheric pollution, oil spills, sewage, cleaning, solid waste, bilge water…

At this point, it is crucial to realise that whatever the problem, it can be fixed when the ship is under construction or when it undergoes modifications. In other words, during shipbuilding or during the process of retrofitting (*"providing a machine with a part, or a place with equipment, that it did not originally have when it was built"*[4]). Indeed, if regulations demand to reduce the speed of ships to consume less energy, for instance, new equipment that can treat ballast waters, or NOx and SOx retainers can be added to ships when they are constructed or undergo the process of retrofit. Therefore, shipyards play the biggest role in the reduction of pollution coming from shipping.

Europe has lost its leading place in shipbuilding. European shipbuilders now struggle to keep the market shares in divisions where they are the best (such as cruise ships). A

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[1] Statista, *Number of ships in the world merchant fleet as of January 1, 2015, by type*, Statista, statista.com, https://www.statista.com/statistics/264024/number-of-merchant-ships-worldwide-by-type/, January 2015, consulted on 09/19/2016

[2] Cluster Maritime Français, *Cluster Maritime Français 2015-2016*, Cluster Maritime Français, cluster-maritime.fr http://www.cluster-maritime.fr/sites/default/files/brochure_cmf_en_2015-2016.pdf, consulted on 06/12/2016

[3] VAN PETEGHEM Marc, *Wind propulsion for commercial ships*, Marine & Oceans, n°249, October/November/December 2015, p.86

[4] Cambridge Dictionnary, *Meaning of retrofit*, http://dictionary.cambridge.org/dictionary/english/retrofit, consulted on 06/12/2016

report published in 2014 by UNTCAD shows that 93% of the ships in the world were built by China, South Korea, and Japan. In the 1960's North-East Asia's reign over the naval industry has started to expand, and never gave up the lead. This period was characterised by the force of Japanese competitiveness which rested on a solid industrial system in which *keiretsu* (conglomerates) were the figureheads, and on the huge Japanese domestic market. 1970-1980 crisis (coupled with very favourable exchange rates) defeated many shipyards in Europe and in Japan, which led to the rise of South Korea as the new champion. It is not only a coincidence. Every player related in the country participated to this miracle. The country conglomerates (*chaebol*) were very active, so was the South Korean Administration. And then, the numerous, hard-working workforce. In 2003, Japanese shipyards had won only 28,2% of the world total order book, and their South Korean rival had won 44,8%. Leaning on the exceptional rise of world trade in the 2000's, China literally flooded the world with its cheap merchandise. To sustain this increase in importation needs as well as exportations', China has resorted to "socialist market economy". This economic system leans on progressive opening of private and public companies to foreign investments through the rise of funds on equity markets. The whole system is supported by a strong political and administrative control on the country's economic activities. Little by little Chinese shipyards have won more and more orders (for simple ships mostly), and in 2009, China officially took the lead of the race with 37% of the world order book, compared to South Korea with 34,3% on competitive grounds. In 2014, this trend was still going on in 2015 with 40,8% for China and 30,9% for South Korea.

	China		Japan		S. Korea		Total	
	Nbr	%	Nbr	%	Nbr	%	Nbr	%
Oil tankers	479	37,96	219	17,35	356	28,21	1054	83,52
Chemical tankers	322	34,33	169	18,02	296	33,56	787	85,91
Gas tankers	69	21,83	103	32,59	125	39,56	297	93,98
Freighters	2414	53,12	1221	26,87	661	14,55	4296	94,54
Container ships	324	33,44	57	5,88	479	49,43	860	88,75
Cargos	776	35,73	450	20,72	123	5,66	1349	62,11
Passenger ships	34	10,66	27	8,46	7	2,19	68	21,31

2010-2014 built fleet (by ships and countries)

Source: ISL

Even if other countries are slowly emerging in the shipbuilding industries (Vietnam, the Philippines for example), there is no doubt that the countries where 93% of global shipbuilding takes place have a tremendous impact on building trends as far as ecology goes through their shipyards.

However controversial as the relation between human society and companies may be, one thing is now certain, it is more entwined than ever and companies are more responsible for their deeds than they ever were. Shipyards are no exception to this phenomenon. Hyundai Heavy Industries (HHI; first shipyard in South Korea) follows a set of rules and regulations as far the construction of its ships goes, such as:

-MARPOL 73/78 annex VI on prevention of air pollution;

*Reg. 13 Nitrogen Oxides – NOx – Tier II & III;

* Reg. 14 Sulphur Oxides – SOX – Particulate matter emission control area – ECA-;

* EU Directive/2005/33/EC, CARB, US EPA ;

- IMO MEPC Green House Gas (GHG Reduction Discussion);

* Energy Efficiency Design Index for New Ships;

- Ballast Water Management (BWM) Convention, 2004;

- ISO 14001 since 2013.

At this point, it is relevant to add that the global economic context regarding shipping and the recent and unexpected bankrupt of Hanjin Shipping (South Korea's first ship-owner) have thrown an ice veil on the ship-owners of the entire world. Already bullied by overcapacity, the shipping sector sunk even lower because of the 2008 subprime crisis and its global economic repercussions. Players already were extremely concerned and the failure of Hanjin Shipping may sound to them like a disarming – yet very insightful – prophecy. Indeed, out of the 12 most important ship-owners in the world, 11 have discarded negative results for the second term of 2016, and are now foreseeing bad results for the following periods.

Rather than spelling the end of shipping, these difficulties should be assessed as an opportunity to transform the industry and adapt it to the reality of the world it should thrive in. As a reminder, it is estimated that there will be 10 billion human beings on earth in 2050. They will need to be fed. More and more countries will develop and gain access to consumer goods. The world needs to find solutions to ensure the well-being of these populations, while stopping the jeopardy of the environment they live in. This includes the availability of resources all over the world, managed and exchanged more

reasonably. Of course, this only stands if the global paradigm of resources' allocation – economic liberalism towards endless consumption – doesn't change. In the event of a strong continuity in the way we have been handling resources and if it becomes more carefully done only, shipping and shipbuilding will remain activities of utmost importance. In this context, the transformation (and most of all, its greening) will be at the centre of attention in the coming months and years.

Therefore, this paper will be divided into three parts. First, I would like to explain how shipbuilding is part of a very intricate group of activities and actors called shipping. This cluster must work hand in hand to reduce the impact of all its activities. One weak link, and the efforts of the others can be reduced to nothingness. Secondly, we will study how South Korean, Chinese, and Japanese shipbuilding industries are composed and how they have managed to nowadays become the centre of attention when shipbuilding is involved. In a third part, we will try to see how North-East Asia shipyards have developed their capacities and technological commitment to meet the needs of eco-transition. We will then widen the debate and see what other kind of transformations the shipping industry can and will resort to in the next years.

"GREEN SHIPPING": THE NECESSARY COLLABORATION BETWEEN SHIP-OWNERS, SHIPYARDS AND PORTS

What does "green shipping" mean? Transporting any given merchandise from somewhere to somewhere else takes ships, of course, but many other infrastructures (ports, shipyards…) must be considered. Indeed, between its starting point and its destination, a ship is either sailing or in a port. These two states don't encompass the same reality as far as green shipping goes. Nevertheless, these realities must be considered. Otherwise, green ships couldn't be considered as relevant. Indeed, consider the greenest ship you could possibly imagine. How could its construction be relevant if no port can welcome it or if the way it was built and its materials are responsible of massive pollution?

That is why, to ensure that "green shipping" develops, efforts must be made on ships of course, but on ports and shipyards as well.

Ships

Most of the solutions for a ship with better environmental performances are built for the time when it is at sea. First, out of many examples, there are numerous ways to reduce fuel consumption. Air bubbles hull lubrication is a method to reduce the resistance between the ship's hull and seawater using air bubbles. By blowing air to the ship underside, a distortion is created across the hull surface, which reduce the resistance of the ship's hull. To this extent, Mitsubishi has created the Mitsubishi Air Lubrication System (MALS). Effects and reductions in emissions and energy-saving of course depend on the type of ship it is deployed on. However, 237 meters, 95,000DWT ship, constructed by Oshima Shipbuilding with plans provided by MHI and sold to FML Ship

Management (Cyprus) has achieved 27% reduction in CO2 emissions, even exceeding the target figure of 25%[5], when normally such technologies are expected to have results of about -10% to -15% emissions.

When the ship is sailing, there are specific ways to minimise its pollution and save fuel. One of them is already largely spread among ship-owners: reduce speed. The impact that reducing a vessel's speed has on fuel consumption and gas emissions is of course closely linked to the weight it transports, the fuel that is used, the efficiency of the engine, etc… But, *"fuel use decreases exponentially as ship speed decreases, leading to substantial cost and CO2 savings"*[6]. A 10% reduction in fleet average speed results in a 19% reduction of emissions of CO2. This technique has the upside of being immediately feasible and even outweighs the cost of its implementation.

Let us consider another way to improve ecological performance. A shift in maritime routes. Global warming is a reality that only a few people still deny and the ice in the Arctic Ocean melts sooner and sooner, reassembles later and later, thinner and thinner. It is expected that by the year 2030, this ocean will be completely free of ice during the summertime. This, of course, awakens an ancient desire to be able to reach Asia from Europe via what we have come to call the North-East Route, sailing along Siberia. Other northern paths exist, such as the North-West Route (sailing along the northern islands of Canada) but the amount of information we have on it is insufficient and the ice is more resilient. Sailing the North-East Route reduces distance between Europe and Chine by 40% (compared to a path by the Suez Canal) and reduces time spent on water by twelve to twenty day. A consequential diminution of fuel consumption and greenhouse gas emissions are expected[7].

Moreover, such systems as kite-sail, rig-sail or solar-sail systems are very efficient (kite-sail system can, indeed, reduce fuel-consumption by 40% annually) but can't be implemented on any ship and are dependent on the weather (kite-sail system as well as rig-sail systems need favourable winds, and solar-sail system needs a favourable sun exposure).

Almost every kind of technological enhancement can be added to a ship via the process of retrofitting. For instance, both air bubbles hull lubrication system and HHI's Hi-FIN (*an energy-saving device attached at the hub of the ship propeller, which generates countering swirls that offset the swirls generated by the propeller, and thus improves propulsion efficiency"*[8]) are simple systems that can easily added to ships during design

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[5] Maritime Cyprus, *New Vessel Achieves 27% Reduction in CO2 Emissions Through Adoption of Mitsubishi Air Lubrication System (MALS) – Ship will be technically managed by FML Ship Management, Cyprus*, Maritime Cyprus, maritimecryprus.com, https://maritimecyprus.com/2014/10/29/new-vessel-achieves-27-reduction-in-co2-emissions-through-adoption-of-mitsubishi-air-lubrication-system-mals-ship-will-be-technically-managed-by-fml-ship-management-cyprus/, October 29th 2014, consulted on 08/11/2016

[6] FABER Jasper & HON Galen & NELISSEN Dagmar & TSIMPLIS Mikis & WANG Haifeng, *Regulated Slow Steaming in Maritime Transport: An Assessment of Options, Costs and Benefits*, Transport Environment, transport environment.org, https://www.transportenvironment.org/sites/te/files/media/Slow%20steaming%20CE%20Delft%20final.pdf page 15, February 2012, consulted on 06/30/2016.

[7] AUTISSIER Isabelle & ORSENA Erik, *Passer par le Nord : La nouvelle route maritime*, Paris, Folio, Folio, 2016, 304 p, p.160

[8] MI News Network, 7 Technologies To Reduce Fuel Consumption Of Ships, Marine Insight, marineinsight.com, http://www.marineinsight.com/tech/7-technologies-to-reduce-fuel-consumption-of-ships/, July 12th 2016, consulted on 07/15/2016

or retrofit. Indeed, the MALS system can, for example can be added on new designed and retrofitted on ships in just fourteen days. So even though a ship has an average lifespan of 20 to 25 years, they can pollute less and less throughout the course of their life, and shipbuilders don't necessarily have to wait to make efforts. But it completely depends on the goodwill and available money of ship-owners.

Ports

Ports play a very important role in the promotion of greener ships. Indeed, the latter require specific installations to be welcomed with a greener equipment. Moreover, ports themselves, as a crucial part of the shipping integrated system, make efforts to smoothen the transition to a greener activity. Indeed, to build greener ships is good, but ports with a bad ecological performance shouldn't spoil their results. On the contrary, they should help shipbuilders reach them.

In order to do so, ports can rely on three direct levers for action, which must translate into lower emissions, lower energy consumption, and thus, lower costs:

- Technologies: just like ships, ports can resort to photovoltaics, wind power, etc. in order to reduce their energy consumption. For instance, the port of Rotterdam uses wind turbine to generate 200 megawatts of energy, which represents approximatively 10% of the total wind power generated in the Netherlands[9]. This energy is used to provide cities and the port itself.

- Renewable energies such as wind, sun, biomass, geothermal facilities: if you consider sun for example, building *"a roof over the stacking area might also be a good solution, keeping sun radiation away and, if equipped with PV panels, also producing energy"*[10].

- Consumption awareness: as energy consumption entered only recently management's focus, many operators are not aware of ports' actual energy consumption. *"Accurately tracking energy consumption requires investment and the establishment of comprehensive monitoring systems composed of meters and recorders for electric power and fuel. Once measurements have begun, managers can then focus on the most promising areas for energy saving by correlating between processes, equipment used, and consumption. Priority should go to areas with realistic reduction potential and a cost-benefit ratio"*[11].

Ports also need to be able to welcome greener ships, and provide them with services related to their status. For example, the port of Marseille has recently equipped with plugs in order to charge ships' batteries. It is thus now capable of welcoming eco-friendlier ships.

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[9] Port of Rotterdam, *Wind Energy,* Port of Rotterdam, portofrotterdam.com, https://www.portofrotterdam.com/en/the-port/sustainability/wind-energy, consulted on 07/01/2016

[10] FROESE Jens & ILLING Diana, *Greener Ports for a Greener Future*, JOC, joc.com, http://www.joc.com/port-news/port-equipment/greener-ports-greener-future_20150608.html, June 8th 2015, consulted on 06/29/2016

[11] *ibid.*

However, harbour installations cannot be changed just like that. It requires time, money, and space, and most of these three elements are lacking. The goal of sustainability is easy to formulate, but harder to achieve, indeed. Ports' installations are constantly solicited. Approximatively 130 vessels are handled in the port of Busan every day[12]. If any of the facility is to undergo work, the whole chain must adapt. First, the port won't be able to process as many operations as it used to, probably resulting in a loss of income. Ship owners also must adapt. Indeed, they must reschedule some trips, or change sailing routine, probably resulting in delays and loss of income as well. Moreover, some ships require specific facilities to be handled because of the size or their content. If infrastructures are under work, the activity of these special ships (which are generally a great source of income) may be simply cancelled, resulting then again, in a loss of income.

Shipyards

As far as shipbuilding *per se* goes, shipyards are the most important piece of the puzzle. Activities undertook in shipyards resort to dangerous chemical products including chromium and lead, while maintenance activities use on a regular basis painting, oil, antifreeze, etc[13]… And pollution can directly fall into water or be carried by "runoff"[14].

Shipyards are companies. As such, they must produce ships that will be bought. This very simplistic point of view features an important consequence: if ship-owners only needed regular cargo ships, why would any shipyard propose other types of ships, that could be eco-friendlier? That is why we can say that in shipbuilding, demand makes supply. However, ship-owners are somewhat reluctant to spend more money than they should because their budgets are often very tight, or if they are not compelled to do so. It has, for example, been proven numerous times that if oil prices were higher, technologies using other sources of energies would develop faster to, someday, cut costs. A recovery in oil price is expected by many experts by 2017, coupled with a continuous trend to replace old fleet with more energy efficient vessels[15]. Those two trends are what is expected to drive the shipbuilding market for the next years, making a transition towards the construction of greener (i.e. with a better energy efficiency) ships a necessity, even if, right now, the market is very tight.

It is very important to remember that the shipping industry is very intricate. Indeed, in order to build greener ships, manufacturers have to ensure that their building path is as ecological as can be. Therefore, heavy transformations of shipyards must take place. The same goes for ports as we have stated. *"Going 'green' is not exactly achievable overnight.*

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[12] Ship Technology, *Port of Busan*, Ship Technology, ship-technology.com, http://www.ship-technology.com/projects/portofbusan/, consulted on 07/02/2016

[13] US National Libreary of Medecine, *Shipyard*, Tox Town, toxtown.nlm.nih.gov, https://toxtown.nlm.nih.gov/text_version/locations.php?id=54, consulted on 07/02/2016

[14] US National Libreary of Medecine, *Urban and Industrial Runoff*, Tox Town, toxtown.nlm.nih.gov, https://toxtown.nlm.nih.gov/text_version/locations.php?id=60, consulted on 07/02/2016

[15] IndustriAll & SAE Europe, *Evolution of Supply, Employment and Skills in the European Maritime Technology Sector*, 2016, p.13

It takes lots of effort from all authorities and parties involved. Until now, implementation of more environmental friendly and 'green' systems are hindered by the costs involved"[16].

However, it is also important to keep in mind that no revolution comes without a price. So, even if enhancements are costly, one day or another they will become compulsory, either because of regulations which become stronger and stronger, or because the situation is already making it so. Indeed, global awareness is growing about the role of the planet. It is the basis, the support of all human activities, and we need it more than it needs us. Its protection should be at the centre of everything and more and more actors in the shipping industry realise it.

Moreover, turning green doesn't only involve costs. Shipyards and ship-owners that already have a foot in the green (among which South Korean's are precursors) are already harvesting the profits of this change of paradigm. *"Thanks to the keen attention Hi-FIN is drawing from ship owners across the globe, HHI has won orders of Hi-FIN for over 30 ships to date, and the company expects more orders now that it can install the device on broader types of ships from LNG (Liquefied Natural Gas) carriers to almost all types of ships including VLCC (Very Large Cargo Carriers), LPG (Liquefied Petroleum Gas) carriers and containerships. If the fuel saving ratio is calculated on the basis of an 8,600 TEU containership, the owners or operators of the containership can save about $750,000 per year or $19 million for 25 years, an estimated lifetime of the ship"*[17].

What is more, a way to accelerate the transition goes through regulation. The pollution of seas, oceans, lakes and rivers is getting more and more obvious and has become a serious matter of discussion in international organisations, among countries, etc… All over the world, regulations are born, more and more severe, such as MARPOL Annex VI, BWM Convention, Hong Kong Convention, Biofouling and Noise Guideline, or IGF Code and Damage Stability (related to safety equipment). The most important of those document is probably the Energy Efficiency Design Index (EEDI). According to this index applied by IMO, ships built on or after 2013 must produce less and less greenhouse gases. -5% by 2015, -10% by 2019, -20% by 2024 and -30% by 2030. The world is realising more and more every day the extraordinary wealth seas offer, as well as the urging need to protect them and exploit it in a wise and durable way. However, building greener ships demands complex equipment and synergy, as well as highly educated naval architects (to design) and crews (to manipulate). All those elements require time and huge investments in R&D and formation. Maritime actors need guarantees that those regulations will be implemented. Therefore, states and international organisations must work closely and be determined to achieve that goal. *"In order to ensure that European companies invest in RDI activities and lead the development in pioneering innovative and greener technologies, there must be certainty about the enforcement and implementation deadlines of those regulations. Delays and postponements in the enforcement of regulations can have a negative effect on first movers"*[18]. Sooner or later,

[16] Max Groups, *GREENER FUTURE OF MARITIME & SHIPPING INDUSTRY: GREEN SHIP*, http://max-groups.com/future-maritime-shipping-green-ship/, Max Groups, max-groups.com, consulted on 07/05/2016

[17] MI News Network, *HHI's New Fuel Saving Propeller Attachment Can Save Up To 2.5 % of Fuel*, Marine Insight, marineinsight.com, http://www.marineinsight.com/shipping-news/hhis-new-fuel-saving-propeller-attachment-can-save-up-to-2-5-of-fuel/, May 7th 2015, consulted on 07/02/2016

[18] IndustriAll & SAE Europe, *Evolution of Supply, Employment and Skills in the European Maritime Technology Sector*, 2016, p.14

ship-owners and shipbuilders will have to comply by those fast-changing and more and more restrictive new regulations. I think there is no going back from this new situation. Now, it is a matter of jumping off the train at the right time (which is now), or head into a wall.

Shipping is an activity that takes place in a deeply intricate environment, in which ship-owners, shipyards and ports are inseparable. The greening of one implies the greening of the others. Via the reductions of costs implied by the development of more and more advanced technologies, and via the regulations that will step by step make it compulsory for ship-owners, shipyards and ports to comply with always stricter laws regarding the environment, the greening of ships will be considered more and more like an evidence.

South Korea, Japan, and – especially for a couple of years – China are considered as lands of technology and innovation. Their shipbuilding industries are nowadays leading in tons ordered and built, and Japan as well as South Korea have as evolved technological capabilities (more than often even better) than the former leading region: Europe. Let us see how they climbed their way to the top of this very complex as well as time and money-consuming activity.

SOUTH KOREA'S, CHINA'S AND JAPAN'S SHIPBUILDING INDUSTRIES

South Korea, China and Japan are considered as rivals in the field of shipbuilding. It is only half-true. Indeed, they fight for the biggest market shares, but their respective areas of specialisation differ most of the time. Indeed, South Korea focus its productive capacities on very high added value ships towards exportation and Japan is still mostly limited to standard ships towards domestic market. The rise of China change the story because it can build cheap ships faster than Japan, and the unstoppable development of its shipyards allow some of them to focus on high value-added vessels and compete with South Korea. Let us see how shipbuilding industries have developed in these three countries.

South Korea

After World War II, South Korea gradually climbed the value-added chain toward more and more sophisticated products assimilating technology from overseas and building up its domestic research and technology (R&D) and scientific capabilities. *"Over time, shipbuilding has become one of Korea's high-technology, innovative industries"*[19]. As we have already stated, today, South Korea's shipyards are the second biggest builders (in terms of numbers of ships built with 30,9% of the world order book in 2014, China's being first with 40,8%) and are considered the best place if you look for container ships or highly sophisticated merchant ships.

[19] OECD Council Working Party on Shipbuilding, *PEER REVIEW OF THE KOREAN SHIPBUILDING INDUSTRY AND RELATED GOVERNMENT POLICIES*, 2015, p.6

There are three constituent elements that one need to emphasize in this industry:

- First of all, its level of concentration. According to KOSHIPA[20], South Korea has 80 shipyards. Nine of them are large companies, and the rest consists of SME's. Around those shipyards used to gravitate about a hundred SME's in the industry of shipbuilding but their number slowly declined. This is a very small number of companies, if you consider Japan or Portugal. This concentration can be explained by the way South Korean economy works as a whole, *chaebols* being the most notorious and proactive part of it.

As far shipbuilding goes, *chaebols* are responsible for most of everything. Indeed, the members of KOSHIPA are almost exclusively conglomerates and account for almost 95% of the country's production[21].

- Its high level of technological commitment. Until the end of the 2000's, South Korea could rely on a price-competitiveness in order to keep its place as the first shipbuilder in the world as Japan couldn't handle such prices. However, China's will to rule its own waters and to become a major player in the field of shipbuilding emerged in the 1990's and was confirmed in the 2000's. That is why South Korea had to resort to product differentiation in order keep the lead[22]. That is why R&D investment in the South Korean shipbuilding industry grew by 74% between 2005 and 2011. In 2012, KOSHIPA member companies invested 281 KRW billion (about 190.6 million euros) in R&D (with an average R&D budgets in companies of 2 to 3%)[23]. *"State's investments also played an important role in that regard. Korean government support for shipbuilding R&D has increased over time, reaching KRW 28.4 billion (USD 25.9 million)* (19,2 million euros) *in 2013 (more than doubling from 2008)"*[24].

- Speaking of which, South Korean State commitment to the success of those companies is one of the reason they were so successful. Shipbuilding is supported by R&D as we have already stated, but also by ship financing via two Export Credit Agencies (ECA)[25]: K-Sure (under the Ministry Of Trade, Industry and Energy) and KEXIM (under Ministry Of Strategy and Finance). *"According to the plan* (of 2009)*, the government asked Eximbank to increase its lending to yards and suppliers by KRW 2.8 trillion (USD 25.6 billion), and K-Sure to increase its insurance by KRW 2.0 trillion (USD 18.3 billion)"*[26]. Then, by 2013, monies committed for export credits and working capital supports increased tenfold compared to 2004.

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[20] The Korea's Shipbuilders' Association was established as a non-profit organization on July 19, 1977 to promote cooperation among members as well as their common interests.
[21] OECD Council Working Party on Shipbuilding, *PEER REVIEW OF THE KOREAN SHIPBUILDING INDUSTRY AND RELATED GOVERNMENT POLICIES*, 2015, p.12
[22] EUN-CHANG Lee, *Korea's Shipbuilding Industry Still Ranks No. 1 in the World*, Korea Focus, koreafocus.or.kr, http://www.koreafocus.or.kr/design2/layout/content_print.asp?group_id=103571, April 2011, consulted on 07/10/2016
[23] OECD Council Working Party on Shipbuilding, *PEER REVIEW OF THE KOREAN SHIPBUILDING INDUSTRY AND RELATED GOVERNMENT POLICIES*, 2015, p.18
[24] *Ibid.*, p.25
[25] State-owned export credit suppliers.
[26] OECD Council Working Party on Shipbuilding, *PEER REVIEW OF THE KOREAN SHIPBUILDING INDUSTRY AND RELATED GOVERNMENT POLICIES*, 2015, p.28

Moreover, more and more special training and educational programs are dedicated to the shipbuilding and offshore industry. The maritime equipment industry also enjoys a good support from the government which holds export consultations and exhibitions for domestic marine equipment industry so that domestic companies can easily access the export market.

China

In China, shipbuilding was seen as a thorough way to develop Chinese economy as it has helped growth in other sectors (such as steel), has imported critical technology and manufacturing best practices from world shipbuilding leaders, and targeted export sales as a means of obtaining hard currency to fuel further economic development[27]. It is not a surprise then, that it was chosen by Chinese Government to be a pillar industry for national economic development.

In 1982, the China State Shipbuilding Corporation (CSSC) was established. It used to control a lot. "*CSSC's mandate included direct control of 153 organizations that ranged from shipyards to technical research and design universities; authority over virtually all military and commercial shipbuilding and repair; power to conduct joint ventures with foreign companies; and ability to negotiate export sales, through the newly established China Shipbuilding Trading Company (CSTC)*"[28]. Even if the CSSC was corporatized to a certain extent, it was still answerable to the Chinese government (as opposed to Japan's *keiretsu* and South Korea's *chaebol*).

In 1999, the CSSC was divided into two separate entities: the CSSC (responsible for most entities in Shanghai and south of the Yangtze river) and the newly emerged China Shipbuilding Industry Corporation (CSIC) established to control the northern part of the country. This division had nothing to do with financial difficulties. Indeed, in another attempt to build a stronger industry in many sectors, China decided to break monopolies in order to make companies compete for domestic government contracts, but also on an international level. Of course, the government still had a great lever of action of those companies. CSSC and CSIC are huge state-owned companies that deal with large-scale business issues. "*Day-to-day operations and most contract bids are handled directly by the shipyards*"[29] they are charged with. Those smaller shipyards act as independent corporate entities that compete with one another and with other countries' companies.

"CSSC and CSIC shipyards account for 70% of China's commercial output but represent only 12% of the total number of shipyards engaged in new construction since the CSSC/CSIC division"[30]. Other entities have jurisdiction over a large number of small shipyards administered by local governments, which have produced 1168 new ships

[27] COLLINS Gabriel, GRUBB Michael C., *A Comprehensive Survey of China's Dynamic Shipbuilding Industry: Commercial Development and Strategic Implications*, U.S. NAVAL WAR COLLEGE, CHINA MARITIME STUDIES, n°1, August 2008, https://www.usnwc.edu/Research---Gaming/China-Maritime-Studies-Institute/Publications/documents/CMS1_Collins-Grubb.aspx p.6
[28] *Ibid*, p.5
[29] *Ibid*, p.10
[30] *Ibid*, p.12

since from 1999 to 2014 (10,7% of the China total). Not very technologically advanced, their huge number allows China to build quickly and with efficiency small and unspecialised ships, which let bigger shipyards open for bigger or more technologically advanced orders.

Some China's ship-owners also control a small numbers of shipyards. They used to focus on repairing their own vessels but they have been building ships in order to supply their own fleets, but also domestic and international buyers. For instance, China Ocean Shipping Company (COSCO), one of the largest shipping company in the country, operates major shipyards in Dalian, Nantong, and Guangzhou. They pursue activities of ship repair, conversion and also new building.

Finally, the Nantong-COSCO KHI Ship Engineering Company (NACKS) is a 50-50 joint-venture between COSCO and the Japanese Kawasaki Heavy Industries. On its own, it built 7,7% of China's total between 1999 and 2014. This success is a blank check for joint-ventures with the international private sector and in 1999 China "*affirmed the importance of the private sector to China's economy and the government openly encouraged shipyards to pursue joint venture development following the bifurcation of CSSC*"[31].

The final feature of the Chinese shipbuilding industry that needs to be emphasised here is the governmental financial support. Through a mix of State subsidies, tax exemptions, reinvested profits and private-sector financing, CSIC has invested in expansions of its Dalian and Bohai Shipbuilding Heavy Industry facilities and *"has multibillion-dollar projects under way to build massive new "shipbuilding bases" on Changxing Island in Shanghai and Longxue Island in Guangzhou*"[32]. These extension projects aim at increasing Chinese shipbuilding capacity in the sector of high-value ships (such as very large containerships, ultra large crude oil carriers, LNG-carriers, etc.) as well as engaging a greening of the sector.

Japan

As early as the 1960's, Japan propelled itself at the spot of leader of the market thanks to cheap labour force, Government incentives, and a very solid conglomerates vertical system called *"keiretsu"*. Indeed, by 1957 its production had surpassed the 1944 peak wartime production level and from the 1960's to the 1980's, the archipelago's shipyards produced about half of all the new ships in the world.

However, the glorious days of the Japanese shipbuilding industry are long gone. Indeed, it slowly lost its competitive advantage to South Korea which emerged as a great shipbuilding nation in the 1980's, 1990's thanks to cheaper wages (Japan had become a wealthy developed country, so wages grew), strong government support, a cheaper currency and an integrated system that resembles *keiretsu* but has some differences with it: *chaebol*. In 2003, South Korean production overtook Japan's.

[31] *Ibid*, p.16
[32] *Ibid*, p.12

One of the most crucial features of the Japanese shipbuilding industry is that the bigger part of its yards are actually focused on smaller vessels. Indeed, the country has more than 1,000 shipyards. Only 26.4% of them are capable of building ship over 500GT and 85,5% can build ships up to 500GT (it may seem that the total exceed 100% and it does, but this is because some shipyards actually build both types).

Most of the time, small shipyards don't have the tools, or the money, or the skills to undertake the construction of highly-specialised ships, which is probably why, in spite of the great overall technological level of Japan, Japanese shipyards still focus on four types of simple ships: bulk carriers, crude oil tankers, general cargo ships, ore carriers. But first South Korean, then, and in a larger extent, China's competition, have injured Japan's industry. For instance, Japan used to produce every single ore carrier in the world in 2007 and in four years, this number plummeted to a little more than 30%. The same goes for bulk carriers. They went from more than 60% to more than 20%.

As far as market goes, more than 80% of ships delivered to domestic owners were built in Japan, as well as more than 90% of maritime equipment. Like for cars, Japan can rest on a very solid and acquired domestic market. This partly explains why most shipyards don't intend to build bigger ships. That is because they don't need to. Indeed, Japanese domestic market (as well as almost every country's for that matter) requires smaller ships than international trade.

However, most builders, as well as the current Government, is willing to expand Japan's potential market share. In order to do so, many shipyards actually have relocated some of their resources to find more welcoming places as far as wages go, for example. Kawasaki Heavy Industries opened shipyards in China, so did Tsuneishi Holdings (they also got one in the Philippines) and Oshima Shipbuilding has established a new shipyard in Vietnam[33].

Japanese shipbuilding industry enjoys a good support from the Government, whoever the people actually involved in this institution. There is a strong continuity, a willingness to reinforce this industrial pillar.

As stated in the OECD report on Japan's shipbuilding industry, those supports have been increasing for several years. Even global economic policies (also known as Abenomics) showed benefits for shipbuilders. Indeed, if Prime Minister Abe's efforts didn't quite convince the whole country or stopped deflation according to some experts, shipbuilders were happy with the *"increase of the stock market to levels not seen since the Lehman Shock"*[34], as well as yen depreciation, which is very profitable to shipyards as yen level is a crucial indicator to know if Japanese yards will be able to take orders or not.

Finally, in spite of economic difficulties and a hostile international market, SAJ's (Shipbuilders Association of Japan) last annual report show that after a catastrophic year 2013 (13.4% of world new orders), Japanese shipbuilding has recovered in 2014

[33] *Ibid.*, p.13 & 14.

[34] LAURSEN Wendy, *Japanese Shipbuilders Benefiting from Abenomics in 2015*, The Maritime Executive, maritime-executive.com, http://www.maritime-executive.com/article/japanese-shipbuilders-benefiting-from-abenomics-in-2015, January 5th 2015, consulted on 08/01/2016

with 23.7% of new orders, and in 2015 with 26.9%. This is encouraging news, although some key-players in the industry foresee a tougher year 2016.

In a world where South Korea and Japan would be the two countries sharing the cake of shipbuilding, this could be an interesting situation for Japan. Indeed, Japan and South Korea traditionally don't focus their efforts on the same ships. In 2014, South Korea built 49,4% of the world's containerships as well as 33,6% of chemical tankers, while Japan built 32,6% of gas carriers and 27,6% of bulk carriers. Both countries are clearly specialised in given types of ships and nowadays, they race for highly technologic ships, less fuel consumption and eco-friendly constructions. In such a world, both countries could compete for the best designer of new and modern ships while staying leader in its own areas and thus not fear competition in these areas, while guaranteeing sources of revenue for these sectors.

However, China emerged as one of the biggest shipbuilding countries in the world in the 1990's, 2000's. The country's shipyards slowly but surely contested both South Korea and Japan's domination in many areas of the shipbuilding industry. If South Korea manages to remain the world's top-builder, it is because it is positioned mostly on highly sophisticated ships that China's companies don't have the capacity to build just yet. On the other hand, Japan is in a complex situation as far as this industry goes. The country players need to find solutions in order to revitalise competitiveness, via a specialisation on highly skill-requesting ships such as green ships, or proceed to a deep restructuration of the industry.

SOUTH KOREA'S, CHINA'S AND JAPAN'S SHIPBUILDING INDUSTRIES ON THEIR WAY TOWARDS ECO-TRANSITION

This part will be dedicated to the way South Korea, China and Japan are allocating their resources in order to emulate the birth and development of an eco-friendlier shipbuilding industry. I chose to study a few specific companies that are particularly involved in eco-shipbuilding because I find it more interesting to put together the profile of companies with a great commitment to the environment, than to write a directory of every single little step or innovation in each country. This allows a more thorough explanation, and this particularly justifies in a field such as eco-transition. This is because most breakthrough innovations require a tremendous amount of time and money to see the light of day. In this context, smaller companies often struggle to emerge. Moreover, in those State-operated industries, smaller companies are more than often primarily used as services and goods suppliers for bigger ones.

South Korea

Hyundai Heavy Industries (HHI)

The company has launched the development of LNG-powered ships in 2009 and has since then never ceased to enhance their products. In 2014, HHI's engineers developed

the main propulsion engine fuelled by LNG (ME-GI engine) in partnership with global engine manufacturers such as MAN Diesel and Wartsila Engine. The company has even created a system in which consumed LNG that evaporate is reintroduced in the engine in an attempt to save as much fuel as possible. Indeed, LNG is precious. Many studies have shown that those systems have a weakness: low oil prices. Just like nowadays, if the oil price is too low, LNG-propulsion projects have a weak economic feasibility. But the company's engineers have more than one trick up their sleeves.

Since they truly believe in the great powers of LNG, they came up with the LNG-Ready technology. Simply put, once this technology applied, after a simple retrofit, the LNG-powered system can function as the facility has already been equipped. This means that ship can use other sources of energy as long as the oil prices are not high enough, and when they are, they can very simply switch to a LNG-powered system. It allows shipbuilders and ship-owners more flexibility and a lower dependence on oil. This technology has even received approval from DNV-GL Group (one of the world's largest classification association), and it was applied to very large containerships ordered in 2013 and 2014 by countries in the Middle East.

HHI also relies on other eco-friendly technologies such as ballast water treatment by ultraviolet sterilisation (Eco-Ballast), or HI-FIN, which we have already talked about.

It is no wonder then, that UASC Umm Qasr, a 9,000 TEU containership built by Hyundai Samho Heavy Industries (an affiliate of HHI) has received the honour of being designated as "Green Ship of the Year" by the Maritime & Port Authority of Singapore. It features an electronically-controlled main engine, a ballast water treatment system and AMP (Alternative Maritime Power) system[35].

Daewoo Shipbuilding & Marine Engineering (DSME)

DSME has been making huge efforts to develop and control green technologies to apply on their ships, in order to, just like HHI, become a competitive company in the field of LNG-powered ships. Moreover, in 2013, the company successfully commercialised its own engine and fuelling system that convert LNG into fuel in partnership with MAN Diesel[36]. The company even applied 200 different patents as far as LNG-propulsion goes (44 of them have been successfully registered as patents).

Nuclear energy is already used to power submarines and icebreakers. Not so much to provide energy to "conventional" ships, such as containers-carriers. Yet, DSME has been trying to develop nuclear energy-powered ships. According to DSME officials, this kind

[35] The Midi Telegraph, *A Boxship Built by Hyundai Samho Heavy Industries Named "Green Ship of the Year"*, The Midi Telegraph, themiditelegraph.com, http://www.themeditelegraph.com/en/shipping/shipowners/2015/04/27/boxship-built-hyundai-samho-heavy-industries-named-green-ship-the-year-PgIBZTBRH6urEWQ7XOPhhO/index.html, April 27th 2015, consulted on 07/21/2016

[36] CHUNGHWAN Lee & SANGHYUN Kim, *Korean shipbuilding industry, Jump into the eco-friendly ship research*, Green Technology Centre, gtck.re.kr, http://www.gtck.re.kr/frt/center/en/tech/green_focus.do?pageMode=View&nttId=22313, December 2015, consulted on 07/11/2016

of ships would be very environmentally friendly because nuclear energy would replace energy coming from fossil fuels and its consumption doesn't produce as much CO2 as traditional energy sources. What is more, those ships would have a very long operation time before fuel replenishment (around 5 years) which would help reduce consumption. It is even considered economically viable as long as the reactor doesn't cost more than 4000$/kW[37].

In addition to building very technologic and environmentally-friendly ships, DSME also encourages a respectful attitude towards environment on the shipyards. Indeed, regular air controls are run around the workplace in order to protect the employees and the neighbourhood. Moreover, during the production of ships, an air pollution prevention system keeps the internal regulation lower than 30% of legal limit. The waste water of the yard is collected, treated at a level lower than 30% of legal limit and then reused on the construction site, rather than being thrown away. The company also carries on coastal clean-up and water purification action through its volunteer campaign *"One company for one clean river".* Chemicals' treatment, usage and discharge are thoroughly controlled by Toxic Chemical Control Regulations. The soil and the underground water are regularly monitored and examined by the inspection agency designated by the Ministry of Environment[38].

China

CSSC & CSIC

As the two most important state-owned shipbuilding conglomerate in the country, CSSC and CSIC must strictly follow the Government's guideline. In May 2015, the Chinese State announced a policy called "Made in China 2025" aimed towards the development of indigenous high-technology production. As a part of this, CSSC created one of the world's first smart ships. "Green Dolphin" is a 38,800 Dead Weight Tons (DWT) bulk carrier based on big data and applies up-to-date information technology including real-time data transmission and collection, large-capacity calculations, digital modelling and remote control. Such technologies are supposed to ensure navigational safety and operational efficiency of the ship. Better operational efficiency means better resources management.

In 2011-2012, CSSC and CSIC's shipyards (CSIC's Tianjin Xingang, CSSC's Chengxi, Yangfan and Guangzhou Wenchong Shipyard Co. Ltd.) got together with the Finnish shipbuilder "Deltamarin" in order to build bulker ships with a very low consumption: the single hull B.Delta 25, handysize B.Delta 37, Supramax B.Delta 64 and Kamsarmax B.Delta 82. "*Both the B.Delta 25 and 37 designs have an Energy Efficiency Design Index (EEDI) value that is more than 20% below the IMO minimum requirement for new-build*

[37] GUIMARES Leonam, *Feasibility Study on Nuclear Propulsion Ship according to Economic Evaluation*, Academia, academia.edu, http://www.academia.edu/7918824/Feasibility Study on Nuclear Propulsion Ship according to Economic Evaluation, May 30th 2013, consulted on 07/10/2016

[38] DSME, *The World's First "Green Shipyard"*, DSME, dsme.co.kr, http://www.dsme.co.kr/epub/management/management060303.do, consulted on 06/30/2016

vessels"[39]. In May 2013, 12 (plus options) of these ships were already ordered, in construction or soon-to-start in Chinese shipyards[40].

Finally, Shanghai Waigaoqiao Shipbuilding Co., Ltd. (SWS), a subsidiary 100% owned by CSSC, signed a newbuilding classification agreement with DNV GL (one of the biggest international classification society) for the construction of three 20.000 TEU ultra-large containerships (the first ever to be built in China) to start in 2018 for COSCO Container Lines Co., Ltd. "*The vessels will be constructed to the highest environmental requirements, meeting the highest EEDI standard and ECA requirements. They also have double-hull protection of fuel tanks and ballast water treatment systems in anticipation of upcoming regulations"*[41]. And *"will have DNV GL's Gas Ready notation, which will give COSCO a much easier pathway for a future conversion to operation with LNG as fuel if so desired*"[42].

COSCO

Among other examples, COSCO, via its shipyard in Guangdong will be responsible for the construction of the "Bonny River", a trailing suction hopper dredger ordered by DEME, a Belgian dredging, environmental and marine engineering group. *"The 'Bonny River' will be able to minimise the turbidity generated by process water and enables dredging in environmentally vulnerable areas. Moreover, the hydrodynamic hull and the dual-fuel engines (diesel and LNG) ensure further optimisation of the fuel consumption and a minimal CO2 footprint"*[43].

China's green shipbuilding capacities are growing, but they are not yet as strong as its South Korean competitor's because the willingness is recent. However, initiatives flourish all over the country. For example, COSCO launched in 2011 a creative design contest for shipbuilding in which the jury awarded the first prize to the 5000TEU hybrid high-speed containership by the COSCO Zhoushan Shipyard Department[44].

From all of these instances, we can come up to several conclusions and hypothesises:

- First of all, the growing numbers of green shipbuilding projects and/or constructions started in Chinese shipyards indicate us that if China cannot compete just yet with South Korea in terms of green ships, it is definitely catching up.

[39] G-Captain, *Green Means Lean: Eco-Ships That Deliver*, G-Captain, gcaptain.com, http://gcaptain.com/green-means-lean-eco-ships-deliver/, March 11th 2013, consulted on 07/12/2016
[40] G-Captain, *Chinese Shipyards Win Orders for Dozen Deltamarin-Designed Bulk Carriers*, G-Captain, gcaptain.com, http://gcaptain.com/chinese-shipyards-orders-dozen/, May 10th 2013, consulted on 07/12/2016
[41] ZHANG Li Xin Cathy, *China's first giants – DNV GL to class SWS built ULCS*, DNV.GL, dnvgl.com, https://www.dnvgl.com/news/china-s-first-giants-dnv-gl-to-class-sws-built-ulcs-48856, consulted on 07/12/2016
[42] *Ibid.*
[43] VANHECKE Marleen, *The latest news from DEME*, DEME, deme-group.com, http://www.deme-group.com/news/deme-orders-newest-generation-trailing-suction-hopper-dredger, consulted on 07/12/2016
[44] Safety4Sea, *COSCO launches creative design contest for green shipping*, Safety4Sea, safety4sea.com, http://www.safety4sea.com/cosco-launches-creative-design-contest-for-green-shipping/, June 14th 2011, consulted on 07/12/2016

- Second, from the examples I have been able to find throughout my study of the subject (many sources were unusable for me because they were written in Chinese), I have come to realise that for the moment China seems to build most of its green ships for other countries. If European companies (such as Deltamarin, DEME, etc.) actually trust Chinese shipbuilders with their green ships, it means that Chinese shipyards have become trustworthy in terms of high technology and skills required to build green ships.
- Finally, against all odds, we could say that China is actually part of the leading countries making efforts for a greener shipping activities.

Japan

Japan Marine United (JMU)

What is very interesting is that this company is trying to compete with South Korea on container-ships which are normally its main field of competence. The "eFuture" series of ships actually realise a 30% reduction in CO2 emissions while sailing. The "eFuture 13000" has a capacity of 13,000 containers which is already a good performance. However, South Korea can build very large container-ships with a capacity of up to 20,000 containers and it has clearly been identified that a global trend as far as shipbuilding goes is gigantism. However, another point of view is shared by experts. Indeed, as pointed out by Murayama, orders of raw materials, for example, are declining. If this trend keeps on going this way, we might see an upturn in the gigantism trend that has taken over shipbuilding in recent years. The small size of JMU's eco-ships may turn out to be an advantage for the company after all. Anyway, the technologies used for this ship (twin-sked hull form, a tip rake propeller, a rudder bulb, low-friction coating, electronic control, waste heat recovery system…) can easily be implanted on container-ships with another size, but most of Japanese shipyards are not able to build much bigger vessels.

However, the real revolution JMU has achieved concerns photovoltaic panels. Indeed, container-ships, for instance, are harder to retrofit than other ships because they need all the surface on the desk to stack containers. The "eFuture 13,000" features a module made of photovoltaic panel with a frame installed above the stacked containers. Using lithium ion batteries installed inboard, the system becomes capable of using natural energy when needed. Of course, this allows the ship to save fuel, reduce gas emissions, but this also has another economic benefit: it may reduce the size and the number of generating plants the ship needs, emptying some space for more containers[45].

JMU also builds "G-series bulk carriers", which achieves a 25% reduction in GHG by improvement of hull performance, construction of a low fuel consumption engine plant,

[45] INOUE Tomohumi, KIDA Takayuki, MASUKO Akira, NAITO Yuji, SAKAGUCHI Katsunori, *Development of Environmentally-Friendly Container Carrier "eFuture 13000C"*, IHI, ihi.co.jp, https://www.ihi.co.jp/var/ezwebin_site/storage/original/application/5a4646c516c619e8720b100ef214f1a7.pdf p.4 & 5.

can travel optimum sea-route thanks to the Japan trademarked navigation system *Sea-Navi* (which happens to also equip eFuture ships)[46].

JMU is a very good example of how Japan intends to recover from years of very difficult market situation and competition. By developing indigenous systems (the *Sea-Navi* system), and develop eco-efficient technologies, the goal appears to be the creation of new supply of basic ships (bulkers for example) and to incorporate them with high-value features that will therefore create a new market on which Chinese shipyards will have a harder time competing. Moreover, Japan clearly tries to diversify its industry by offering a new expertise on container-ships which is normally South Korea playground. Japan can count on innovative companies such as JMU to diversify its supply range and strengthen its indigenous forces.

Mitsubishi Heavy Industries (MHI)

MHI has created the Mitsubishi Air Lubrication System (MALS), as already stated.

Another one of MHI's indigenous technology is its pod-propulsion system. It allows the propellers to rotate to any horizontal angle, replacing the couple rudder/propeller and allowing a better manoeuvrability for the ship. The usage of pods grew during the 1990's. MHI's CRP-POD system allows energy saving for more than 13% than the traditional direction/propulsion couple[47].

MHI's other eco-friendly technologies include Mitsubishi reaction fin, Mitsubishi stator fin, Mitsubishi hub vortex free cap, solar power system (for CO2 emissions reduction), as well as LNG as fuel technology (MHI-GEMS) and emission abatement technology (MHI-EGCS) for NOx reduction. All of those technologies can be added to ships for 1,000, 2,600, 3,600, 4,900, 10,000 and 18,000TEU containerships, many bulk carriers (35,000, 37,000 and 38,000DWT), as well as the company's LPG carriers and chemical tankers[48]. Others are in development.

Even though the contract with Aida Cruises ended up a huge financial loss for MHI, nevertheless, when the first ship was delivered in March 2016, it was very much celebrated. Indeed, this ship is a technological nest. *"The AIDAprima is the world's first cruise ship equipped with the "Mitsubishi Air Lubrication System" (MALS), MHI's proprietary technology that enhances fuel efficiency. Other cutting-edge technologies that save energy, increase automation and reduce manpower needs include a pod propulsion system, liquefied natural gas (LNG) fuel supply system, the latest gas emissions treatment system, and a new air-conditioning system that saves on energy consumption by using waste heat. The AIDAprima is also equipped with state-of-the-art technologies to ensure*

[46] JFE, JFE Technical Report: *"G-Series" Bulk Carrier*, JFE, jfe-steel.co.jp, March 2014, http://www.jfe-steel.co.jp/en/research/report/019/pdf/019-39.pdf, consulted on 08/03/2016

[47] FUJITA Shigemoto, KITAMURA Tohru, OSHIMA Akira, UEDA Naoki, UNSEKI Takashi, TAKEDA Shingen, *The First Hybrid CRP-POD Driven Fast ROPAX Ferry in the World*, MHI, mhi-global.com, https://www.mhi-global.com/company/technology/review/abstracte-41-6-9.html, consulted on 08/05/2016

[48] MHI, *Mitsubishi Emission reduction technology*, MLIT, mlit.go.jp, http://www.mlit.go.jp/common/001095319.pdf, June 2015, consulted on 08/07/2016

safety onboard. Together these features make the AIDAprima a next-generation large cruise ship sure to make every AIDA cruise a unique and special experience"[49].

MHI may have lost money on this contract, but we can assume that it was nonetheless a very useful business:

- First, we can consider it a "trial by error" kind of deal. Indeed, the "Commercial Aviation & Transportation Systems" division of the company was still healthy despite this loss. But MHI has surely gained know-how in construction, knowledge in contracts, etc., which may prevent such mistakes to occur again in the future.

- Second, the deal didn't conclude with profits for MHI. But it is possible that it has established the company as a rival in the field of cruise shipbuilding. This is one of the few areas of construction that still belongs to European shipbuilders. Every Asian shipyard that has tried to position itself on this sector has experienced big troubles, as MHI did on the financial aspect. But it is not the only company. Indeed, even South Korean big companies have experienced some kind of troubles. However, MHI's indigenous technology may prevail in the long run and provide Japan with a new area of expertise that will help the country gain competitiveness over its North-East Asian rivals.

The necessity to adapt for ship-owners

As stated in the beginning of this paper, the crisis undergone by Hanjin Shipbuilding in South Korea has led to great questioning in the shipping industry (which is closely tied to shipbuilding as we know). Entangled in an overcapacity situation for which any cure will take time to be effective, ship-owners and shipbuilders, moreover, acknowledge the finitude of the global economy to a wider extent. What is more, companies all over the world are reorganising their value chains in order to protect themselves from suffering again from the devastating effects of the 2008 economic crisis. They have engaged the construction of production sites closer to local markets. Indeed, General Electrics now builds engine spare parts where they are needed rather than shipping them from the USA. Consequently, in 2015 – for the first time since the 1950's, if we don't count the 2009 recession – global GDP had risen faster than containers' traffic.

Time for change! Several paths are under study right now. First, the ecological transition, which we have discussed throughout this paper. On the one hand, under the action of the IMO, it will become more and more compulsory to comply with environmental standard. On the other hand, it is profitable. The following chart[50] shows

[49] MHI, *MHI Completes Delivery of "AIDAprima," a New-Generation Cruise Ship, to AIDA Cruises -- Ship Sets Sail for Hamburg, Germany* --, MHI, mhi-global.com, http://www.mhi-global.com/news/story/1603141967.html, March 14th 2016, consulted on 08/15/2016

[50] FABER Jasper & HON Galen & NELISSEN Dagmar & TSIMPLIS Mikis & WANG Haifeng, *Regulated Slow Steaming in Maritime Transport: An Assessment of Options, Costs and Benefits*, Transport Environment, transport environment.org, https://www.transportenvironment.org/sites/te/files/media/Slow%20steaming%20CE%20Delft%20final.pdf p. 101, consulted on 06/30/2016

how profits (mentioned here as negative "net costs") appear on every considered speed reduction scenarios, even at low fuel prices.

Net present value (billion USD)									
Speed reduction	-25%			-20%			-15%		
Fuel price scenario	Low	Base	High	Low	Base	High	Low	Base	High
Costs for purchase extra ships	668	668	668	476	476	476	327	327	327
Fuel expenditure extra fleet	350	575	663	261	425	490	197	320	369
Other annual expend. extra fleet	431	431	431	310	310	310	214	214	214
Change of fuel expend. baseline fleet	-1262	-2069	-2387	-938	-1529	-1764	-697	-1133	-1307
Engine modification costs	26	26	26	25	25	25	24	24	24
Extra inventory costs	759	759	759	516	516	516	343	343	343
Change of external costs									
– Costs operational CO_2	-298	-298	-298	-229	-229	-229	-172	-172	-172
– Shipbuilding CO_2	19	19	19	12	12	12	7	7	7
– No_x	-608	-608	-608	-453	-453	-453	-335	-335	-335
– BC	-5	-5	-5	-4	-4	-4	-3	-3	-3
– SO_x	-150	-150	-150	-114	-114	-114	-84	-84	-84
Net costs	**-70**	**-653**	**-883**	**-137**	**-564**	**-734**	**-178**	**-491**	**-617**

Moreover, if a ship has to travel ECA (Emission Control Area) zones (which are not the majority of areas in the world but their numbers and surface are expending under the influence of IMO) less than ¼ of the year, it will be profitable for the company that handles it in a short amount of time after the installation of a SOx scrubber, as proven by Yara Marine Technology's VP Sales and Marketing: Kai Låtun presented it during the GREEN4SEA Forum 2015[51].

What is more, Sometimes, shipbuilders and ship-owners receive heavy incentives to become greener. Singapore-flagged ships can thus enjoy a reduction of 75% of initial registration fees and 50% rebate on annual tonnage tax if they adopt both energy efficient ship designs and approved SOx scrubber technology exceeding IMO's requirements[52], for instance.

Gatherings also win supports. Maersk and SMC have already joined forces to create 2M, the world's leading ship-owners' group. A few weeks ago, CMA-CGM, COSCO Container Lines, Evergreen Line and Orient Overseas Container Line have created the Ocean Alliance in order to compete with 2M in terms of number of ships and capacities, but also as a guarantee of survival in case of particularly troubled times. Moreover, alliances have several upsides: routes sharing, joint-filling of containers in order to cut operating costs of giga-ships (already cheaper per transported ton).

Innovative management strategies are developing in order to adjust the industry to the reality of the situation it is in. For example, the empty container exchange allows to exchange unused equipment between ship-owners, operators, and other logistics companies.

South Korea, China and Japan are among the most advanced countries in the world as far as shipbuilding goes and, to a lesser extent eco-shipbuilding as well. The eco-transition

[51] Green4Sea, *SOx scrubbers; a profitable investment*, Green4Sea, green4sea.com,

http://www.green4sea.com/sox-scrubbers-a-profitable-investment/, May 29th 2015, consulted on 09/03/2016

[52] Institute of Marine Engineering, Science and Technology, *Green Ship Technologies*, IMAREST, imarest.org, http://www.imarest.org/all-docman-documents/publications/round-tables/682-green-ship-technologies/file, p.10, consulted on 09/04/2016.

the world is engaged in in several fields is powerful in shipbuilding in these countries. The latter rely on technologically very advanced companies such as DSME, MHI or CSSC which have already met some tremendous ecological, as well as economic success regarding their eco-friendly technologies.

Shipping and shipbuilding industries have been experiencing several years of gloom, and the bankruptcy threat of Hanjin Shipping has given the final blow to the few sceptics about the state of this industry. The eco-transformation of the way ships are built is part of a wider change in the way shipping (and so shipbuilding) will operate in the next few years. Adaptation to this new situation is the key, and only the fittest and the most willing to question their certitudes will survive. The rest is headed to a brick wall.

CONCLUSION

Shipping is responsible for the emissions of 5% of human greenhouse gas emissions, which is gigantic. That is why, thanks to a tremendous scientific participation (which we have to carry on because the ocean is still mostly unknown), for twenty years or so, a trend has been developing among all of those actors when populations and companies have realised how important the ocean is for the survival of our planet. So shipbuilders, ports and ship-owners of the world are trying to find solutions to foster their economic development while reducing their negative impact on the environment.

Nowadays, many of them are already existing or soon will be. It goes from kite-sail systems which can reduce fuel consumption by 20 to 40% annually, solar-sail systems which can save fuel up to 20%, modifications on propellers, exhaust scrubbers which reduce emissions of SOx, NOx and CO2 up to 98%. But we could also talk about magnificent progress made to treat ballast waters or in design of ships for them not to carry ballast waters at all… As far as ports are concerned, they need to be more vigilant with their everyday activities, initiate recycling systems, and most of all be sure to be able to welcome greener ships among their installations (for example, ships tend to be partly powered by electricity by the means of batteries nowadays. Ports, therefore, need stations where they can charge up their batteries), otherwise they could lose frequentation and therefore money. Ship-owners also make efforts as they reduce the sailing speed of their ships and are more inclined to buy eco-friendly ships in spite of the financial problems many of them are facing. But it actually is a sort of unavoidable investment because as regulations evolve, sooner or later, green ships will no longer be known as green ships but “standard ships”, and the sooner the players get comfortable with this reality, the better for them and the world.

The shipbuilding industry in North-East Asia is very important for the countries it concerns. They took the lead in the race during the 1950’s (Japan) and soon South Korea and China followed, and nowadays more than 90% of the world’s merchant fleet was built or is currently being built in the shipyards of these three countries. However, competition is very strong between them. As building capacities and skills evolve and grow, especially in China, the three rivals tend to be able to supply the ships that feature the same amount of capacity, technology, and so on. In order to survive, shipyards have to evolve to constantly be one step ahead of the competition. This is where eco-

specialisation enters. Indeed, such specialisation requires a large amount of skills, money and technology in order to be even just considerable for companies. South Korea dove first into this transition and the country's shipyards are now renowned as the most technological and skill-efficient shipyards in the world. They are home of some of the most innovative companies (HHI, SHI, DSME, etc.) regrouped in the capitalistic form of chaebol. On the other hand, China is on the rise. It has developed a strong shipbuilding industry in the 1990's and is a fierce competitor in the sector for South Korea and Japan since the 2000's. China has even acquired some skills and production means to develop its own green shipbuilding industry which could, someday, hinder South Korean and Japanese eco-friendly development. This new trend in China is symbolised by high-tech shipyards such as COSCO ad well as the public CSSC and CSIC, which European companies such as Deltamarin even trust regarding the building of their green ships. If China keeps supportive innovative shipyards, this promises a shift in the world's shipbuilding industry due to China's overall competitiveness.

On a global scale, shipping and shipbuilding industries are challenged nowadays because of the state of the economy worldwide, as well as the overcapacity crisis the players have to deal with. This is why, among other adaptation paths, the eco-transition is regarded as one of the most accessible goal. However, accessible or not, it is a matter of survival for the entire planet. This reality is encompassed by the way the IMO tries to regulate emissions and pollution, and make it compulsory. Ship-owners and ship builders will have to comply sooner or later. Only the fittest will survive this transition.

Eco-friendly policies can be considered relevant in the world we are living in because they are needed in order to shelter the Earth and its populations. But are they economically efficient? Most studies tend to show that they are. For instance, for the installation of an SOx scrubbers on a ship sailing all year long in an ECA zone, the company will see return on investment in 0,887 years. If the ship sails 80 days per year in such a zone, it is 4,5818 years. Moreover, reducing the speed of a ship is profitable on almost any oil price scenario and almost any speed reduction scenario. This is due to tax exemptions, savings on fuel, and so on. However, the largest impact would be socio-economical. Indeed, studies tend to show that, for instance, container shipping will potentially grow by 400% in 2030, compared to 2007. Its socio-economic impact will grow proportionally, and under the "business as usual" scenario, the cost is estimated at 7.62 billion dollars. However, with METS (a potential new regulation on greenhouse gas), this amount drops to 3.1 billion dollars for the same year. This is 4.52 billion dollars of negative externalities that will be saved.

On the other hand, the threats that weigh on the environment is probably the biggest global challenge the international community has to face. Their resolution requires a general agreement on the direction to take and actions to undertake for the sake of the Earth and its populations. This is why, we can think that ecology is a matter that belongs in international relations. More than belonging, it is said that it could bring an end to the realist scheme of international relations we are in, which requires a power balance almost only measured by hard power. If armed threats are still very acute nowadays, it is impossible that the Earth will remain relatively calm as it is right now in the event of more natural catastrophes occurring because of we didn't do what was necessary to save the world from an environmental crisis. The new-coming generation of people will

put even more pressure and the Earth and starvation, numbers of unsheltered people, tensions around water, etc. will grow. Those questions need to be addressed by serious collective answers and we can only hope the world leaders will soon find an agreement. What is more, it is a way for a country to appear as an advocate for the environment and advance towards more international recognition (China's case typically).

As a matter of fact, eco-friendly policies in industries (be it shipbuilding or anything else) actually encompass a wider array of fundamental areas of reflexion. The deeper we go, the more we realise how intricate industries, States and world governance are intertwined. By investing, trying to specialise in eco-shipbuilding and cooperating in the application of new regulations as well as in the construction of greener ships (in spite of their sometimes troubled relations), North-East Asia countries are actually showing with their own renowned pragmatism that it is time to act in favour of the environment in order to save the human. ■

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TOWARDS A MORE SUSTAINABLE WORLD:

The Example of Shipbuilding in North-East Asia

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