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Analysis of the marine equipment industry and its challenges

This report is contributing to Output Result 1.2.2.3 of the WP6 PWB for 2021-22. on "Marine equipment industry and its challenges".

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1. Executive summary

1. This report analyses the global marine equipment industry, which is a key supplier and input sector to shipbuilding production processes. It provides an overview of both recent market developments and ongoing trends as well as factors impacting marine equipment manufacturers, notably government strategies, intellectual property rights, counterfeiting, pirated goods and technology transfer practices.

2. First, the report tries to offer a clear definition and delineation of the marine equipment industry as well as a framework by which to categorise marine equipment producers. Marine equipment commonly refers to machinery, parts and raw materials used for the building, conversion, and maintenance of ships. Due to the fragmentation and heterogeneity of the marine equipment sector and lack of internationally accepted classification, however, clear identification of marine equipment companies can prove difficult. Global marine equipment value chains also appear significantly more complex than value chains of other industrial sectors, such automotive and the aircraft industries, given the large number of marine suppliers at both the first tier and second tier levels.

3. Second, the report provides an overview of current market developments. In terms of market share, the European Union is the world's largest supplier of marine equipment (including services), followed by Korea, China and Japan. In the marine diesel engine market, which is the largest trade segment in marine equipment, the EU posted net exports of USD 12.9 billion between 2019 and 2020, making it the largest exporter. The EU also leads the global export market for marine turbines, propellers and blades. Japan is the dominant exporter in the outboard motor market, with exports reaching USD 37.2 billion in the past two years, which is about 1.9 times the total export value of the EU, the United States and China during the same period. Japan is also a leading exporter in the marine reciprocating engine market. It shows the various structures of marine equipment sectors.

4. Third, the marine equipment industry, as the main upstream sector for the shipbuilding industry, is an important source of employment in many countries. Research by the German Federal Ministry for Economic Affairs and Energy (BMWi) shows that one job in the shipbuilding industry leads to the generation in total of 10 jobs.

5. Fourth, various mid- to long-term market trends are affecting the marine equipment sector, with the COVID-19 crisis notably highlighting challenges to resilience of global value chains. Further, while the paradigm of the shipbuilding industry is rapidly shifting to eco-friendly ships in line with the International Maritime Organisation's (IMO) goal of reducing greenhouse gas emissions, the digitalisation of the shipbuilding and marine equipment industries is expected to accelerate the 'smartisation' of ships and autonomous ship operation. This 'twin transition' of decarbonisation and digitalisation has the potential to drastically impact marine equipment technologies and change maritime business models and the maritime transport industry.

6. Fifth, the document provides a comprehensive overview of general government strategies and relevant targeted policies for the marine equipment sector in Japan, Korea, the European Union, United Kingdom and China. Furthermore, it discusses, and offers case studies on, key developments affecting the industry in areas such as intellectual property rights, counterfeiting, pirated goods and technology transfer practices.

7. Finally, key policy recommendations are presented. To address challenges linked to recent market developments and long-term trends, policies targeting the marine equipment sector need to be centred around governments providing adequate technical support, paying more attention to patent management, preventing illegal leakage of technologies and sensitive data and developing human and institutional capacities.

2. Introduction

8. The shipbuilding industry is an industry that assembles hundreds of types of equipment and materials. The proportion of equipment and materials in the total cost of shipbuilding varies depending on the type and size of a ship, but generally ranges between 55 and 60 per cent[1]. In addition, the quality of equipment affects the performance of a ship. However, despite the important role of the marine equipment sector as a key input to the shipbuilding industry, this sector has not yet been studied in-depth by the OECD Council Working Party on Shipbuilding (WP6).

9. As discussed during the 2019 WP6 workshop on marine equipment, this sector is highly fragmented and heterogeneous, raising statistical challenges notably linked to the question of what should be considered as "marine equipment". This paper overviews the structure of the global marine equipment industry, following a broad definition including services, focusing on international trade of the main marine equipment and industrial specialisations of selected economies.

10. In addition, the document summarises selected reports and articles dealing with policy issues related to the marine equipment sector and touching upon issues such as intellectual property rights, counterfeiting, pirated goods and technology transfer practices. This document raises policy issues that are important to address in the marine equipment sector. These issues are also important for the WP6 as the marine sector and maritime clusters have very large economic impacts. Moreover, in some countries, operators complain about government support in competitor countries; this can tilt the competitive playing field between shipbuilders and harm the health of the industry.

11. The Secretariat would like to express its gratitude to WP6 members and marine equipment associations for having provided very valuable inputs and looks forward to ongoing cooperation with them on this project.

[1] https://www.shippingnewsnet.com/news/articleView.html?idxno=17616

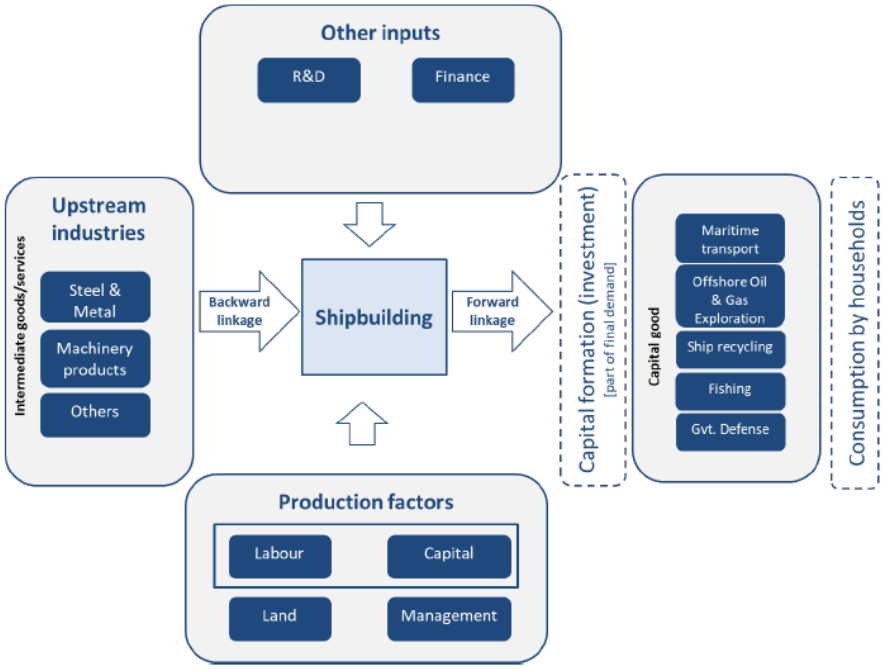
3. Scope of the marine equipment industry

3.1. Role of the marine equipment industry in shipbuilding supply chains

12. Shipbuilding relies heavily on supplied inputs of other industries, with approximatively 70 to 80% of the final output value of ship production being generated through the upstream supply chain (OECD, 2019a). While in the past shipyards were often responsible for the production of most main equipment, nowadays sourcing covers almost every phase performed in shipbuilding, resulting in the development of so-called "assembly shipyards" (Mello et al., 2015). Consequently, the shipbuilding supply chain can be subdivided into several segments: shipyards and boatyards, component suppliers and material suppliers (such as steel and metals) and subcontractors providing different types of services. Marine equipment manufacturers are a key part of maritime component suppliers.

13. Figure 1 provides an overview of the main industries participating in the shipbuilding production process, with steel and metals and machinery products as major suppliers (upstream industries) and maritime transport, offshore oil and gas and ship recycling etc. as end-users (European Commission, 2017).

Figure 1. Overview of main industries involved in the shipbuilding production process

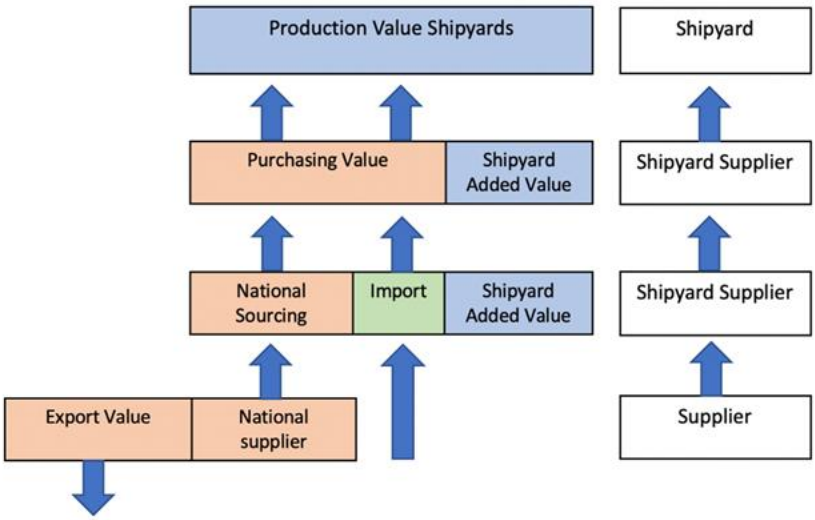


Source: OECD (2019a)

14. The shipbuilding production chain is characterised by a pyramidal structure distribution. Given, the large number of companies supplying the shipbuilding industry its value chain is highly complex, with significantly more first tier suppliers and subcontractors than in other industries. Whereas in the automotive and aerospace industry manufacturers progressively concentrate on "platform suppliers" with less than 500 suppliers at that level, shipyards work with a much higher number of suppliers and subcontractors directly. This can lead to between 1000-2500 companies in the purchasing database, depending on company size and ship-types (European Commission, 2017).

15. Figure 2 shows a more detailed breakdown of supply chains between shipyards and their suppliers, as well as the corresponding exported and imported production values at each stage of the supply chain. Shipyards acquire marine components (including equipment) from various domestic suppliers ('national sourcing') and foreign suppliers ('imports'). This substantial use of external inputs by shipyards is reflected in the fact that the majority of a ship's value added being created by suppliers and not shipyards themselves. Marine suppliers can directly supply domestic shipyards ('national supplier') or export to foreign companies, thereby offering goods and services for the global market in addition to domestic production.

Figure 2. Simplified structure of the global supply chain between shipyards and suppliers



Source: adapted from European Commission (2017)

3.2. Components of the marine equipment industry

16. Marine equipment commonly refers to machinery, parts, and raw materials used for the building, conversion, and maintenance of ships. Some service sub-sectors such as engineering, design and consulting are also included in the marine equipment sector, as shown in Table 1.

Table 1. Selected products and services that could be included in the marine equipment sector

Group	Item
External services and subcontracts	● Engineering, design, and consulting
Materials	● Steel / ● Pipes and ducts / ● Paint, coating
System / Equipment	● Ship operation ● Cargo handling equipment and special cargo plants ● Accommodation ● Propulsion, power generation ● Auxiliary systems, apparatus & accessories for engine operation, ship operation, cargo handling, accommodation ● Electrical plants and electronic system

Source: "Competitive position and future opportunities of the European marine supplies industry (2017)", BALance Technology Consulting.

17. Unlike the shipbuilding industry, there is no internationally accepted classification to easily identify and analyse the marine equipment industry. The marine equipment industry does not exist in official statistics[2]; for instance, the Industrial Standard Industrial Classification of all economic activities (ISIC) and the North American Industry Classification System (NAICS) do not distinguish marine equipment manufacturing as a separate industry category.

18. Furthermore, marine equipment suppliers that furnish products and services to shipyards include several industry categories. For example, a manufacturer of communication equipment for a ship belongs to the category of communication equipment manufacturing and a producer of marine paints belongs to the category of paint manufacturing. Therefore, information about the marine equipment industry provided by business associations, research institutes, etc. is often different and difficult to compare.

19. In some cases, marine equipment manufacturers sell services in addition to manufacturing products. For instance, marine equipment manufacturers can export services primarily in connection with their export and sales of marine equipment, components and materials, e.g. in terms of aftersales service packages. Some maritime service companies also send out employees to repair and service ships and offshore installations at sea or at third country ports or yards.

20. Against this backdrop, associations in major shipbuilding economies that represent the marine equipment industry define the scope of their industry differently, often reflecting their domestic situation. The European Shipbuilding and Maritime Equipment Association (SEA Europe) defines maritime equipment suppliers as follows: "Maritime equipment suppliers deliver materials, systems, and components; act as service providers in engineering and consulting; or are integrated as subcontractors in pre-product manufacturing and assembly". The European Union (EU) has a specific legislative instrument on maritime equipment, which also deploys a definition of marine equipment (Official Journal of the European Union, 2014). On the other hand, marine equipment industry associations in Japan, Korea, and China limit the scope of the marine equipment industry to manufacturing and classify marine equipment products accordingly in statistical surveys.

21. Given the various existing definitions for the marine equipment sector, it is important to adopt a comparable definition for this study. For purposes of data collection and cross-country comparisons, the Secretariat will use the following broad definition of marine equipment:

[2] Renne Taudal Poulsen, "Diverting developments – the Danish shipbuilding and marine equipment industries, 1970-2010". 2013

Box 3.1. Definition of marine equipment

'Marine equipment encompasses:

- any type of equipment such as a system, component or material;
- relating to the maritime sector;
- that is (to be) incorporated in the ship or that by way of its function is related to the operation and/or exploitation of the ship's activities, including pre-product manufacturing and assembly.

Examples of marine equipment include engine monitoring, steering gears, propulsion, propeller, engine controls, sensors, doors, windows, anchors, lightning, tanks and filtration, marine pumps, deck equipment, clocks and barometers, gangway and hatches, safety equipment, and hydraulics.

Marine equipment also includes technical services for the building, conversion, and maintenance of ships, such as ship engineering, design, consulting and aftersales service.

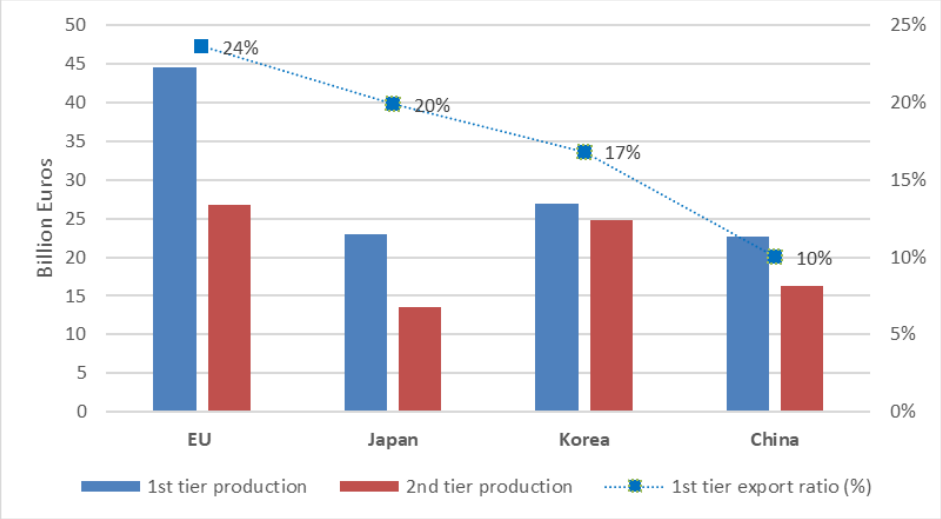
4. Overview of the marine equipment industry

4.1. Global production and exports

22. BALance Technology Consulting recently conducted a study on the Shipbuilding Supply Chain Statistics (2019) to estimate the production and export values of marine suppliers in major shipbuilding economies. The company did so by using its shipbuilding value chain model for the statistical evaluation.[3]

23. According to this study, the European Union was the world's largest supplier of marine equipment (including services), with an average production value of EUR 71.3 billion between 2010 and 2014, followed by Korea, China, and Japan. During the same period, the European Union ranked as the world's largest exporter of marine equipment (including services), exporting an average of 24 per cent of production value of 1st tier marine suppliers outside the European Union (see Figure 3).

Figure 3. Production and export ratio of marine suppliers in selected economies, average for the period 2010-2014



Note: 1st tier marine suppliers supply materials, components, systems, engineering, design, etc. directly to shipyards, and 2nd tier suppliers supply these to 1st tier suppliers. "Export ratio" means the share of exports in total turnover. The EU export figure does not include Intra EU trade.
Source: European Commission (2017)

24. The types of major marine equipment used in shipbuilding can be broadly classified as shown in Table 2 based on the Harmonized System (HS) code[4] used to categorise goods in international trade statistics. The ship-specific items in the presented HS codes are turbines for marine propulsion, marine propulsion system, and propellers and blades.

[3] This model includes 1st and 2nd tier suppliers within the value chain of shipbuilding and distinguishes further import and exports markets with Europe and the rest of world respectively. The study makes use of averaged statistical data for industrial groups available in different public databases, i.e. Eurostat, OECD, national statistics etc.

[4] The Harmonized System is an international nomenclature for the classification of products. It allows participating countries to classify traded goods on a common basis for customs purposes. At the international level, the Harmonized System (HS) for classifying goods is a six-digit code system.

Table 2. Shipbuilding subassemblies, components and raw materials by HS code

System Group	Specific to ships	Item	HS code
Platform: Propulsion	Yes	Turbines for marine propulsion	840610
		Marine propulsion engines: diesel or semi-diesel engine	840810
		Marine propulsion engines: Outboard motors Spark-ignition reciprocating or rotary engines, for marine propulsion	840721 840729
	No	Nuclear reactors, boilers, machinery /other engines and motors	841229
		Parts for use with spark-ignition internal combustion engines	840991
		Parts applied to ship and auto for engines other than internal combustion	840999
Mechanical	Yes	Propeller & blades	848710
	No	Other machinery self-propelled, others	842649
Navigation & Communication	No	Radar apparatus, radio navigational aid apparatus and radio remote control	8526
		Surveying, hydrographic, oceanographic, hydrological, or instruments and appliances.	9015
		Navigation-related	901480 901490
Hull/ Raw materials	NO	Steel (iron & iron-alloy)	7206-7217
		Tube & Pipes & fitting	7303-7307

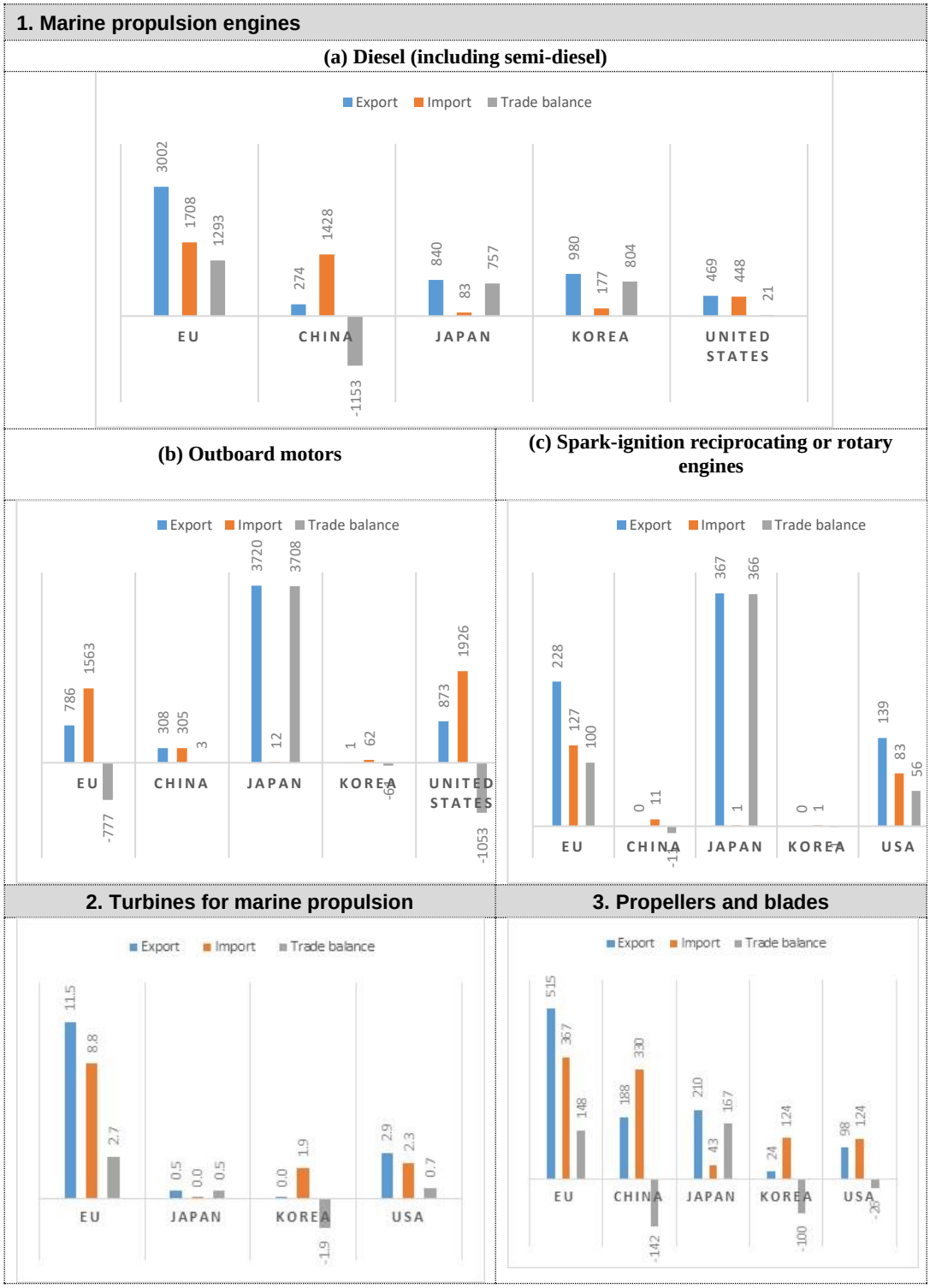
Source: Duke GVC Center (2017)

25. Figure 4 shows the trade balances of the EU, China, Japan, Korea, and the United States for five ship-specific marine equipment sub-sectors over the past two years (2019-2020). Overall, the EU and Japan occupy a leading position in the global trade of these segments.

26. In the marine diesel engine market, the largest trade segment in marine equipment, the EU posted net exports of USD 12.9 billion between 2019 and 2020, making it the largest exporter. The EU also leads the global export market for marine turbines, propellers and blades. Japan is the largest exporter in the outboard motor market. Japanese outboard motor manufacturers exported USD 3.7 billion in the past two years, which is about 1.9 times the total export value of the EU, the United States and China during the same period. Japan is also a leading exporter in the marine reciprocating engine market.

27. China relies heavily on imports of marine diesel engines as well as propellers and blades and has a significant trade deficit for these products. Korea is a net importer of the other items, excluding marine diesel engines with net exports of USD 8 billion. The United States had a big trade deficit of USD 1.1 billion with respect to outboard motors in 2019 and 2020, but there were no significant imbalances between exports and imports for marine diesel engines, turbines, propellers and blades.

Figure 4. Trade of ship-specific marine equipment by selected economy, 2019-2020
in million USD



Note: EU figures exclude intra EU trade data and China's trade for marine turbine is not available at this database. Amounts denominated in JPY and Euro are converted to USD using annual average annual exchange rates (https://www.irs.gov)
Source: Global trade statistics database of Korean International Trade Association (https://stat.kita.net)

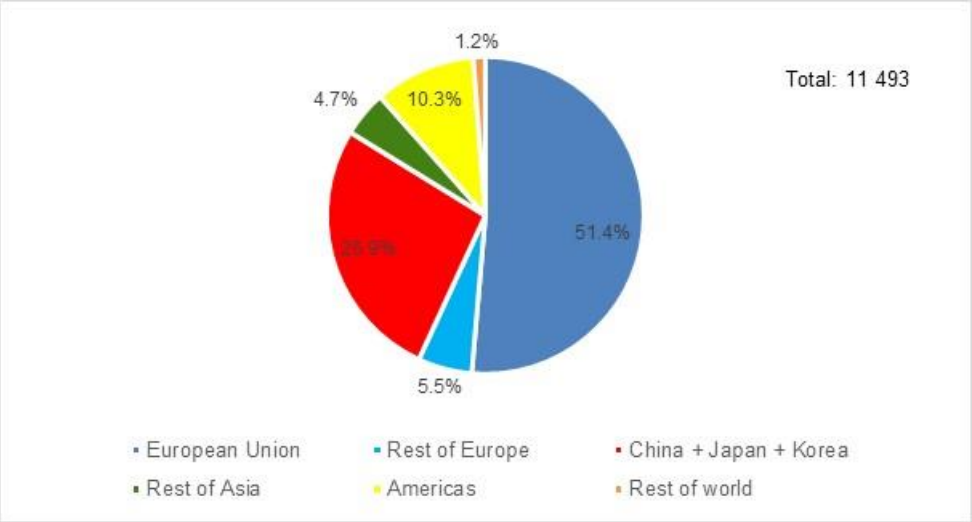
4.2. Market developments in selected marine equipment economies

4.2.1. EU Member States, the United Kingdom, Norway and Türkiye (countries of SEA Europe members)

28. The European marine equipment industry is an important producer of advanced marine equipment, systems, and technologies. European marine equipment manufacturers produce nearly 50 per cent of the world's marine equipment (SEA Europe, 2019a).

29. According to BALance Technology Consulting, as of 2013, there were 11,493 marine supply companies worldwide, of which 6,539 (57 per cent) were located in Europe.

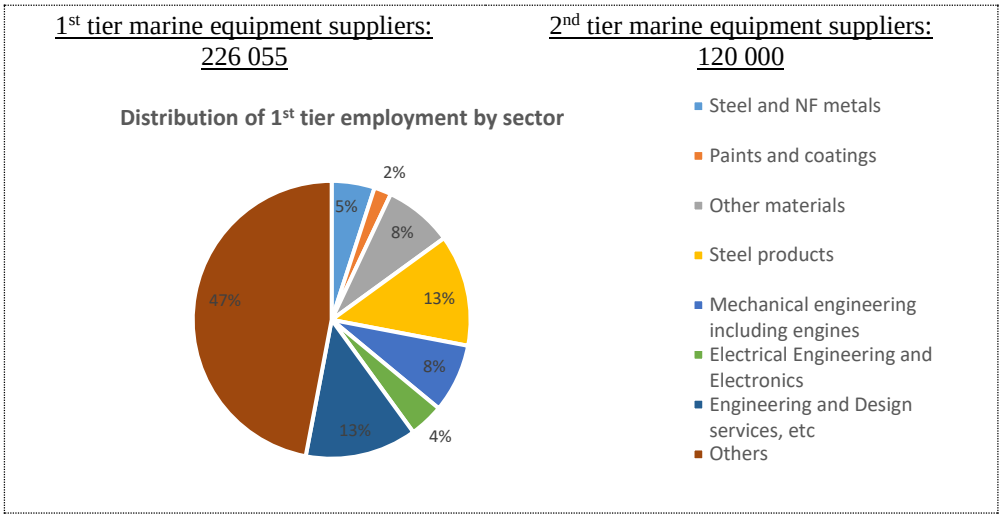
Figure 5. Distribution of marine suppliers by region of interest, 2013



Source: BALance Technology Consulting (2017)

30. According to SEA Europe, maritime equipment suppliers in the countries of SEA Europe members generated an output averaging of EUR 81.6 billion between 2012 and 2016 and employed about 346,000 people.

Figure 6. Direct employment in the marine equipment industry in the SEA Europe region, 2012-2016.



Source: SEA Europe (2019b)

European Union

31. Between 2012-17, the production value of the EU marine equipment sector was estimated to EUR 71.6 billion, according to a statistical analysis carried out in 2019 (BALance Technology Consulting, 2019), with a production value of:

    - EUR 44.5 billion for the first tier of the EU maritime equipment supply chain
    - EUR 27.1 billion for the second tier of the EU maritime equipment supply chain

32. Direct employment of EU marine equipment companies stood at 324 000 direct jobs (2012-17 average), according to the statistical analysis carried out by BALance Technology Consulting (2019), divided as follows:

    - 217,000 direct jobs in the first tier maritime equipment supply chain
    - 107,000 direct jobs in the second tier maritime equipment supply chain

Box 4.1. Maritime value-added and employment in Germany

A recent report (BMWi, 2021) on the maritime economy in Germany aims to quantify the value-added and employment of the various sectors of the maritime economy.

The analysis covers all maritime sub-sectors, such as shipbuilding, shipping, offshore, ports or fisheries, and shows the effect on the overall value-added. The result shows that the maritime economy secured a total of 449,800 jobs in 2018 with a value-added of EUR 29.8 billion and a turnover of EUR 86.3 billion. 100 jobs in the maritime economy thus secure further 130 jobs in Germany.

26,400 employees work directly in the German shipbuilding industry (including 8,900 in the industry producing boats for inland waterways). Including indirect jobs, this amounts to 82,800 workers (with 32,200 working in maritime companies and 23,100 working in non-specifically maritime companies in the value-chain). Including 21,600 induced jobs, there are 104,400 people working for the German shipbuilding industry

63,000 employees work directly (121,500 including indirect jobs) in the German marine equipment industry (including services). 33,600 induced jobs can be added which means that 155,100 employees for the German marine equipment industry and 258,400 jobs related to the German shipbuilding and marine equipment industries.

According to this study, one job in the German shipbuilding industry generates nine additional jobs if we include jobs created in the shipbuilding and marine equipment industry value chains.

33. Marine equipment manufacturing in Europe is a highly export-oriented activity. Whereas the export rate of individual EU countries lies in the range 20% – 76%, the export share of the aggregated EU region was estimated to equate to about 33% of the total production value in 2012-17. For 1st tier suppliers, the export value was estimated to EUR 25 billion (approximately 55% of production value). The export rate of major European countries in the field of marine equipment is usually well over 50 per cent. For example, the export rate for Germany, the largest marine equipment supplier in Europe, was 76% in 2020. Europe and Asia are the main export markets for German suppliers, accounting for 34% of total exports.

Table 3. Key indicators for marine and offshore equipment suppliers in Germany, 2020

Revenue	EUR 10.5 billion
Employment	63 000
Export rate	76%
- Export share by region	Europe : 34% Asia: 34% (China 18%, Korea 9%, etc.) Others: 32%

Source: VDMA's website (German mechanical engineering industry association)

34. Europe is currently the largest global producer and supplier of advanced maritime equipment, systems, and climate-friendly technologies. This may be related to the sector's continuous investments in highly skilled workforce as well as in research, development, and innovation.

35. Among types of marine equipment, technologies and solutions where Europe holds a strong position are ship engines, boilers, pumps, life-saving equipment, marine coating solutions, scrubbers, ballast water treatment systems, design solutions.

36. The European marine supplies industry includes two different groups. On the one hand, there are global players who are active in one or more marine markets and one or more supply trades - typically represented by the top 100 companies in the sector (i.e. a few large or medium sized companies). On the other hand, the vast majority of companies which are dependent on regional maritime markets or even on single maritime customers- (i.e. a large number of small and medium sized enterprises (SMEs) often also located in the close proximity of shipyards or in localities (including cross border) with intensive maritime activities.

37. At EU level, SEA Europe is the main association, representing close to 100% of the European maritime technology sector (encompassing both shipyards and marine equipment companies) in 16 European nations, including Türkiye and Norway. SEA Europe's member national associations represent maritime equipment companies at national level as well as at EU level mainly through SEA Europe.

38. In some Member States, the marine equipment sector is represented by more than one association. For instance, in Germany the marine equipment sector is represented by VSM (which is a member of SEA Europe) but also by VDMA, the association of Germany's engineering industry (which is not member of SEA Europe).

39. Some marine equipment companies are also represented through other international or European sectoral associations, such as EGCSA (European Gas Cleaning System Association), EUROMOT (European Association of Internal Combustion Engine Manufacturers), CEPE (coating industry), or more horizontal associations such as ORGALIM which represent Europe's technology industries.

Norway

40. In 2020, the maritime equipment industry in Norway had a total revenue of close to NOK 150 billion (EUR 15.85 billion or USD 17.33 billion) and a value added of NOK 40 billion (EUR 4.23 billion or USD 4.33 billion) and employed around 34 thousand people. Average productivity is higher in the maritime equipment sector than in other Norwegian manufacturing companies, with value added per employee of EUR 130,000 and EUR 85,000, respectively (Menon Economics, 2021). The report by Menon Economics (2021) also noted that the effect of the Covid-19 Pandemic on the Norwegian maritime sector has been limited in 2020, especially compared to the effect of the oil price shock in 2014/2015.

41. Approximately 90 percent of all maritime equipment suppliers are SMEs, and this group of firms employ 40 percent of all employees in the industry. Besides being an SME, the typical Norwegian maritime equipment supplier is located in rural areas along the coast, outside of the big cities in Norway (Menon, 2021).

Republic of Türkiye

42. Türkiye's marine equipment sector is closely interlinked with its shipbuilding sector and supplies a wide range of technology components to local shipyards. Turkish manufacturers are active on mid-level technology segments of shipbuilding, including deck equipment, electrical equipment, cables, ship chains and anchors. For some high-end technology items, such as main engines, navigation equipment and telecommunication systems, Turkish shipyards are still dependent on foreign suppliers (see Table 4 below).

43. Türkiye's main exported marine equipment parts are marine propulsion engines, reaching a value of USD 4.1 million in 2017. European countries make up the highest share of export markets for Turkish marine equipment (see Table 5 below).

44. Employing an estimated 60,000 people by the end of 2018, the marine equipment industry is one of Türkiye's sectors with the highest potential in terms of employment (OECD, 2021a).

45. The main industry representative body is the Turkish Association of Ship Industrialists (GESAD), which aims inter alia to enhance the cooperation of marine equipment suppliers, shipyards and education-training-research institutions and promote safe and environmentally clean technologies (OECD, 2021a).

Table 4. Main equipment produced in Türkiye and imported from abroad

Production in Türkiye	Imported from abroad
Steel cast material	Steel sheets and profiles
Welding and cutting equipment	Navigation devices
Diesel generator	Communication devices
Deck machinery	Propellers
Boilers and compressors	Bow and stern thrusters
Valves, piping, and pumps	
Ventilation systems	
Electrical equipment and cabling	
Hatch doors, doors, windows, scuttles and woodwork	

Source: OECD, 2021a

Table 5. Main ship equipment exports and export markets

Equipment	Export Value in 2017 (USD million)	Major Export Markets in 2017
Anchors, grapnels and parts thereof, of iron or steel	1.9	Czech Republic (32.3%), USA (16.7%), The Netherlands (12.9%)
Outboard motors	0.8	TRNC (27.10%), USA (16.4%), Istanbul Free Zone (12.1%)
Outboard motors, other	0.1	Greece (31%), Italy (20.4%)
Marine propulsion engines	4.1	Kocaeli Free Zone (40.9%), Denmark (32.2%), Iran (9.10%)
Ships' propellers and blades thereof	0.6	Kocaeli Free Zone (25.8%), Germany (12.3%), Adana Yumurtalık Free Zone (7.1%)
Total	7.7	Kocaeli Free Zone (40.9%), Iran (3.5%), Czech Republic (4.1%), USA (3.9%)

Source: Turkish Directorate General of Exports (2018)

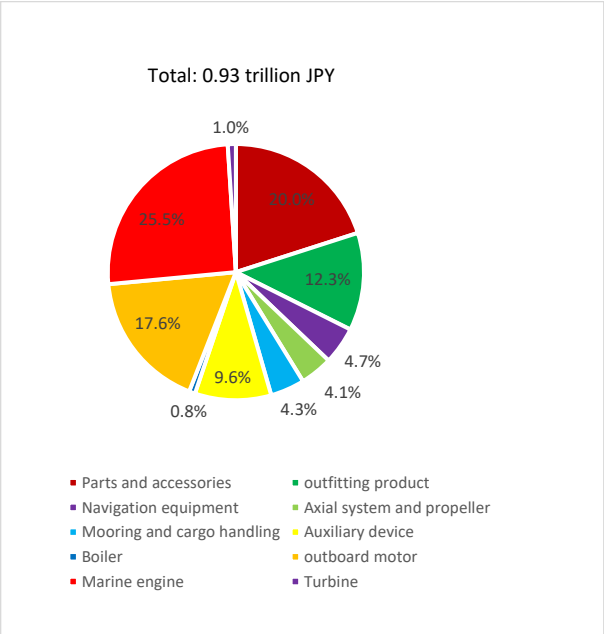
4.2.2. Japan

46. Most of the marine equipment required for ships built in Japan is produced domestically; the country's ratio of self-sufficiency in marine equipment is about 87%. A significant portion of its production is exported abroad; in particular, Japan occupies a large share in the global market for outboard motors, navigation systems, ship pumps, propellers, etc.

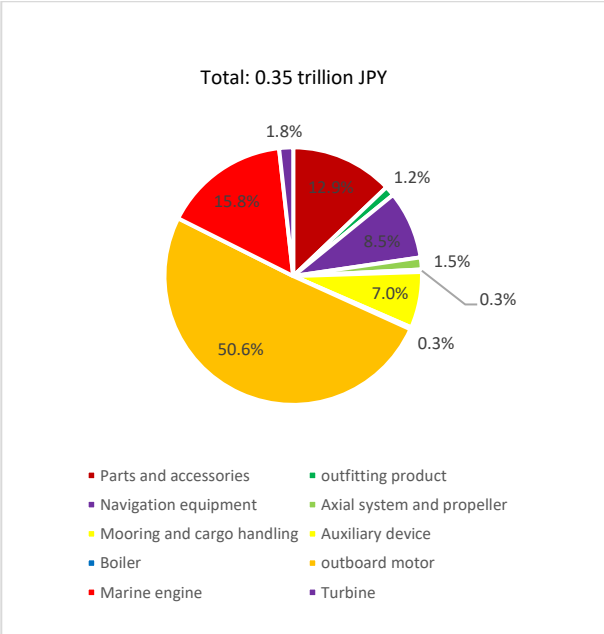
47. According to the Maritime Report 2021 of the Ministry of Land, Infrastructure and Tourism (MLIT) [5], which focuses only on the manufacturing sector, there were about 1,100 marine equipment manufacturers in Japan, which employed about 41,000 people and generated sales of JPY 0.94 trillion in 2019. Total exports amounted to JPY 0.36 trillion, accounting for about 38% of the total revenues of these companies. The number of plants owned by marine equipment suppliers amounted to 692 as of December 2019.

Figure 7. Product portfolio of Japanese marine equipment industry in 2019

(a) Production



(b) Exports



Source: 海事レポート(Maritime Report) 2021, MLIT

48. The main products of Japanese marine equipment manufacturers include marine diesel engines and outboard motors. In 2020, Japan produced 8,723 diesel engines (JPY 204 billion) and 277,230 outboard motors (JPY 105 billion).

[5] Annual Report of the Ship Machinery and Equipment Statistics (published by MLIT in 2019) https://www.mlit.go.jp/common/001354733.pdf

Table 6. Main products of Japanese marine equipment industry in 2020

Product	Quantity	Amount (Billion JPY)
1. Diesel Engines	8,723	204
- less than 1 000 PS	6,575	28
- 1 000 PS or more and less than 10 000 PS	1,905	74
- 10 000 or more	243	102
2. Outboard motors	277,230	105
3. Pumps	29,019	26
4. Electrical equipment	31,958	21
5. Cargo handling machines	669	13
Total	-	369

Source: 造船造機統計調査 (Shipbuilding machinery statistics survey) 2020, MLIT

49. Japan Ship Machinery and Equipment Association (JSMEA) represents the marine equipment sector in Japan.

4.2.3. Korea

50. Korean shipbuilders rely significantly on imports for eco-technology related equipment but source about 90 per cent of their marine equipment domestically. However, many of these suppliers are licensees of foreign companies, which sell licenses related to the manufacturing of marine products in a third country. These services can be provided cross border, via local establishment or by posting temporarily an employee from the foreign marine equipment company abroad.

51. According to the 2020 Report by the Ministry of Trade, Industry and Energy which includes a Statistical Survey of the Shipbuilding Equipment Industry, there are about 2,700 companies in the Korean marine equipment industry, with sales of about USD 20 billion, exports of about USD 3 billion and about 73,000 employees as of 2019.

52. As of 2020, there were 265 marine equipment manufacturers affiliated with the Korean Marine Equipment Association (KOMEA), concentrated in Busan and Gyeongnam province, which are adjacent to Korea's three big shipyards.

53. According to KOMEA, the total sales revenue of the association's member companies was KRW 18 trillion in 2020. Their total exports amounted to USD 1.2 billion, accounting for about 8% of the total revenue. The largest export market for Korean marine equipment manufacturers is Asia, and as of 2019, China, Japan, and Singapore accounted for 51% of the Korea's total exports of marine equipment.

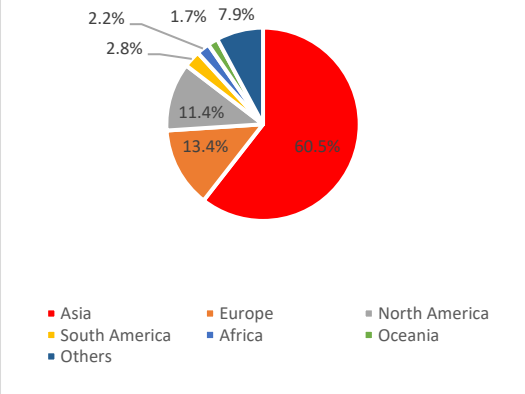
Table 7. Performances of Korean marine equipment industry in 2020

Product Category	Employment	Production (Billion KRW)	Direct export (Million USD)
1. Hull (Chemical products, welding material, casting and forging, etc.)	3,068	1,652	151
2. Engine and machinery (Diesel engine, turbine, propeller, generator, etc.)	4,508	1,642	403
3. Outfitting (Steering, navigation, mooring, cargo arrangement, safety and accommodation, etc.)	14,681	6,899	321
4. Electrical and Electronic (Power arrangement, wiring, lighting, communication system, etc.)	6,406	6,629	328
5. Others	2,223	1,164	-
Total	**30,886**	**17,986**	**1,203**

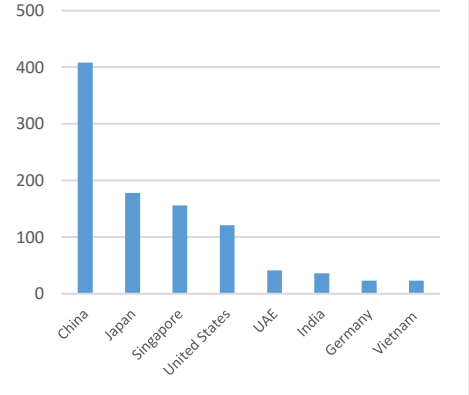
Note: These figures are based on the survey of member companies of the KOMEA
Source: Korean Marine Equipment Association (KOMEA)

Figure 8. Exports of Korean marine equipment in 2019

(a) Exports by continent (%)



(b) Major destination of exports (million USD)



Note: These figures are based on the survey of member companies of the KOMEA
Source: Korean Marine Equipment Association (KOMEA)

54. The marine equipment industry is closely linked to the shipbuilding industry and the number of ships ordered by domestic shipping companies has a great influence on its performance. In addition, the shipowner's preference as well as technology are important especially for eco-friendly equipment, for which demand rose recently. The Korean marine equipment industry maintains its global competitiveness in existing markets such as ship engines. In terms of size, it appears to be the fourth largest after EU, China and Japan.

55. There is some vertical integration with major domestic shipyards, including Hyundai Heavy Industries, producing shipbuilding and related equipment (e.g. Hyundai Heavy Industries' HiMSEN engines, etc.). In addition, R&D and production of equipment are conducted through consortiums with subsidiaries or equipment companies[6].

[6] https://biz.chosun.com/industry/company/2021/06/22/ACDGLYYJHFBV5DP32UQ3LUCK7U/

56. The Korea Marine Equipment Association (KOMEA) and the Korean Marine Equipment Research Institute (KOMERI) are the Korean marine equipment associations.

4.2.4. China

57. According to the China Association of National Shipbuilding Industry (CANSI), there were 420 marine equipment manufacturers in 2018. Major enterprises were state-owned, many of which are affiliates of China State Shipbuilding Association (CSSC), the largest Chinese shipbuilding conglomerate, accounting for 40% of ship production in China.

58. According to CANSI, the total sales revenue of the marine equipment industry was CNY 55.3 billion (USD 8.1 billion) and total profits were CNY 3.75 billion (USD 0.55 billion) in 2018. The main products produced by China's marine equipment manufacturers are marine diesel engines. In 2018, China produced 11,272 marine diesel engines with a capacity of 9.3 million kW. China is a world-renowned marine diesel engine manufacturer, along with European countries, Japan and Korea, accounting for one third of global production in 2017. After marine diesel engines, deck machinery and cabin equipment also make up a major part of China's marine equipment production (OECD, 2021b).

Table 8. Major products of China's marine equipment industry in 2018

Product	Quantity
1. Power system and device	
Low speed diesel engine	223 units (3,759 thousand kW)
Medium speed diesel engine	5,525 units (4,069 thousand kW)
High speed diesel engine	5,524 units (1,518 thousand kW)
Propulsion device	161 pieces
Low speed diesel engine crankshaft	169 pieces
2. Deck machinery	
Mooring equipment	1,082 units
Loading and unloading equipment	374 units
Steering gear	205 units
Anchor chain	177,060 tons
3. Cabin equipment	
Fan	4,804 units
Marine boiler	26 units
Marine environment protection equipment	261 units

Source: 中國船舶工業年鑑2019 [China shipbuilding industry yearbook 2019], CANSI (2019)

59. For high-tech product lines, such as high-end diesel engines, propulsion systems, and communication and navigation equipment, China still relies heavily on imports from the EU, Korea and Japan. In 2017, China's total imports of marine equipment amounted to USD 1.45 billion and exports to USD 0.97 billion (Market Research, 2020). The Chinese government has introduced several policies to increase the domestic production share of marine equipment, in particular for high-tech ships (further detailed in Section 6. "Policy Framework").

5. Main market trends

60. The maritime sector is a salient example of an industry simultaneously affected by decarbonisation efforts and digitalisation. This so-called 'twin transition' has the potential to drastically change maritime business models, ship construction and vessel operation and, as such, is expected to have a strong impact on marine equipment markets and global value chains. Three key considerations for the uptake of 'green' and digital marine equipment technologies include their level of technical maturity, the applicability to ship types and the ease of installation and required investment and payback time.

61. The following three subsections provide an overview of 1) recent trends in global markets and global value chains (GVCs) of marine equipment products 2) the impact of decarbonisation efforts on marine equipment markets and 3) the impact of digitalisation on marine equipment markets.

5.1. Global Markets and Value Chains

62. The marine equipment industry shows a high level of diversification and heterogeneity of markets. The customer base of marine equipment companies not only consists of shipyards but also ship repair companies, shipping companies, research institutions, offshore oil & gas operators, offshore wind operators and underwater operators (BALance Technology Consulting, 2019). Manufacturing firms within the marine equipment industry can be sub-divided into numerous categories differing in size and market specialization (see Table 9).

Table 9. Overview of types of marine equipment companies in maritime markets

Global market leaders and industrial generalists with significant maritime market shares	• Industrial generalists or market leaders for one or more technological sub-markets that supplies the maritime as well as other industrial sectors • Companies tend to have significant global maritime market shares but relatively lower maritime revenue shares
Global or regional maritime specialist companies	• 'Big players' in their respective maritime technological sectors which frequently serve maritime markets locally and abroad • Makers of specialized marine equipment that often have type approvals with one or more classification societies
Localized regional or domestic maritime specialist companies	• Smaller companies that essentially supply only localized regional or national markets • The growth of localized cross-border or domestic maritime markets is extremely important to these suppliers

Source: adapted from European Commission (2017) and BALance Technology Consulting (2019)

63. Previous OECD analysis on GVCs in shipbuilding found that among major shipbuilding nations machinery and equipment had a significant foreign market share, making up 10% for China and 12% for Japan. Korea sources more than 25% of ship machinery and equipment from foreign suppliers. By contrast, Europe has a particularly strong position in marine equipment worldwide and acts as a net exporter (OECD, 2019a).

64. A consequence of the high level of global outsourcing in the shipbuilding supply chain, the shipbuilding process necessitates considerable coordination skill: workers need to assemble thousands of different components, which have to be correctly manufactured and arrive at the right place at the right time. For example, ships are assembled from up to 550,000 parts in the case of complex research vessel or 900,000 parts for cruise ships (SEA Europe, 2017). Shipyards thus need to possess effective systems as well as management and

organisational skills in order to generate information, develop production plans, control materials and achieve high quality standards in the production of components.

65. The level of complexity, fragmentation and outsourcing in the shipbuilding supply chain makes uncertainty, even for standard ship components, relatively high. As a market of custom-made products, marine equipment companies often do not have a stock of finished products to satisfy specific customer needs and a lack of integration, communication and coordination between partners of the same supply chain risks affecting product quality and the delivery date, raising uncertainty for suppliers throughout the network (Mello et al., 2015).

66. Like shipyards and their customers, manufacturers of marine equipment are subject to cyclicality (but to a lower extent when they also produce goods for other downstream industries). All things being equal, a decline in ship orders would lead to an adaptation of shipyards' production plans, reductions in their demand for inputs and, consequently, a reduction in demand for equipment suppliers.

67. Supply and demand shocks in the maritime industry caused by the COVID-19 crisis strongly impacted the marine equipment sector and highlighted the need for supply chain resilience and efficient coordination of the supply base. The past two years have seen increased research into systemic factors creating uncertainty in shipbuilding supply chains as well as methods to counteract them, in particular through different types of supply chain (risk) management (Alfnes et al., 2021 & Chu et al., 2021).

5.2. Decarbonisation

68. Ship owners, operators and builders are increasingly using 'green' technologies to comply with environmental rules and regulations. Parts of the IMO Green House Gas (GHG) short-term measures to reduce emissions directly target equipment designs of ships and are expected to strongly impact the marine equipment market. Key regulations in this aspect are the Energy Efficiency Design Index (EEDI) as well as the 2023 IMO regulation on the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII). The EEDI and EEXI are technical standards that assess the theoretical efficiency of newbuild and existing vessels based on design and equipment, and are aimed at encouraging investment in improved vessel designs and potential newbuild installation of energy saving technologies (ESTs). The CII, which measures the carbon intensity of ships in operation, may also incentivise alternative fuels, design improvements and ESTs.

69. Apart from more stringent environmental regulation, important maritime decarbonisation trends that incentivise the development and use of 'green' marine equipment are rising fuel costs, (future) use of alternative fuels, voluntary commitments to green finance and investments and digitalisation. These levers of decarbonisation can significantly impact the marine equipment market and world fleet uptake of equipment for alternative fuels and energy saving technologies. According to the "Global Marine Technology Trends 2030" report by Lloyd's Register al. (2015), decarbonisation efforts impact marine technology innovation and development through three key channels:

    - Gradual advancement of an already-established technology, such as main propulsion with a more effective slow-speed diesel engine;
    - Novel equipment and propulsion arrangements, such as hybrid propulsion systems;
    - Wider use and commercialisation of innovative new technologies, such as hull air lubrication or sail-assisted propulsion.

70. While uncertainty in the market over different alternative fuel types persists, alternative fuels are gaining traction (making up 44% of the orderbook in 2022 compared to 14% in 2017). LNG fuel capable adoption has dominated ordering, with a recent increased focus on methanol, hydrogen and ammonia and a further trend to optionality. This has significant implications for the marine equipment products , for example, for engine designs to reduce methane slip or to offer future fuel flexibility. There has also been in increased uptake of battery propulsion or a battery/diesel combination, especially in smaller and coastal vessels, such as ferry, tug and offshore (Clarksons World Fleet Register, 2022).

71. With regard to scrubbers, approximately 4,700 vessels representing around 360 million GT in the active fleet are fitted with SOx scrubbers. While the uptake of SOx scrubbers increased rapidly during 2019 in preparation for the IMO 2020 global sulphur cap, installation of the equipment slowed significantly from 2020 onwards, despite an increase in price premium for LSFO compared to HSFO. In the medium to long-term, there is a chance that carbon capture and storage systems (CO2 scrubbers) will become increasingly attractive as a possible solution for ship owners to cut emissions. However, while there have been a series of small-scale CCS systems projects undertaken in 2022, CCS technology remains at the pilot stage and is currently not commercially or technologically viable, with high costs and low capture rates due to storage limitations (Clarksons Research, 2022).

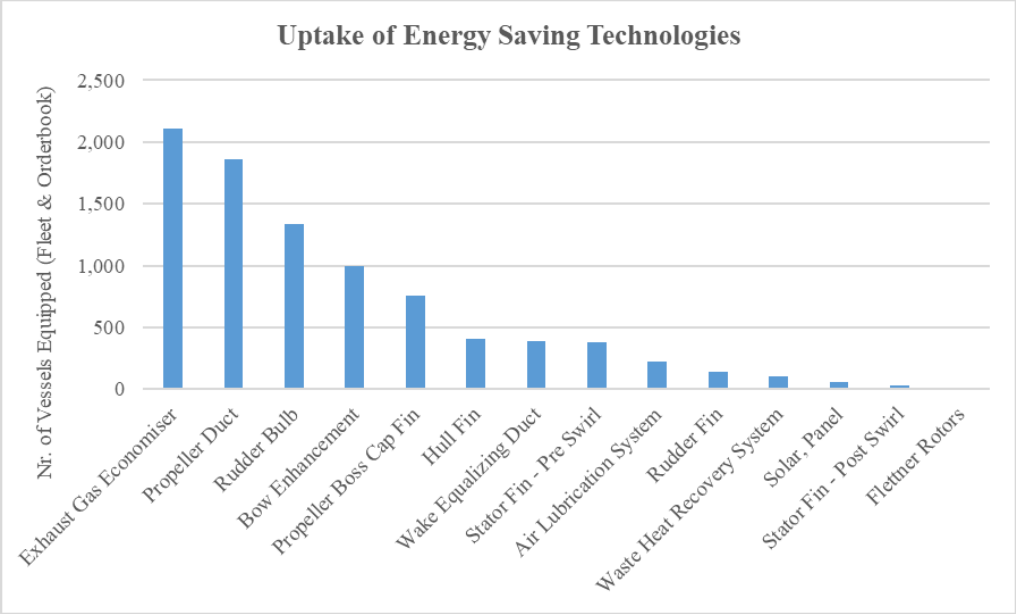
72. Besides equipment linked to alternative fuel adoption, marine energy savings technologies are experiencing an uptick in research and deployment, with an expected further increase in adoption in the future. Table 10 provides an overview of key EST equipment types that ship owners are investing in as well as estimates on fuel savings. Data from Clarksons World Fleet Register (2022) shows that more than 5,000 vessels have significant ESTs (compared to around 3,000 in 2017) and 24% of world tonnage is fitted with an energy saving technology, with 33% of boxship fleet tonnage, 28% of tanker fleet tonnage and 22% of bulker fleet tonnage fitted respectively.

Table 10. Examples of Energy Saving Technologies (ETS) equipment

Equipment Type	**Technology**	**Fuel Savings**	**Vessels Equipped (Fleet & Orderbook)**
Propulsion	Propeller Duct	3-8%	>1,854
	Preswirl Stator	4-6%	>360
	Rudder Bulb	3-5%	>1,306
	Wake Equalizing Duct	6-10%	>392
	Propeller Boss Cap Fin	2-5%	>733
Engine room	Waste Heat Recovery	3-8%	>105
	Exhaust Gas Economiser	4-6%	>2,091
Hull	Air Lubrication System	5-10%	>233
	Bow Enhancement	4-10%	>993
	Hull Fin	2-5%	>409
Deck Equipment	Flettner Rotors	7-10%	>18
	Rigid Sail	8-30%	>8
	Wind Kite	Up to 20%	>2
	Solar Sail	Up to 20%	>1

Source: Adapted from Clarksons Research, 2022

Figure 9. Energy Saving Technologies Uptake in Fleet and Orderbook by Oct 2022



Source: Clarksons World Fleet Register (accessed Oct 2022)

73. Figure 9 indicates the uptake of energy saving technologies in the current fleet and orderbook. Exhaust gas economisers show the highest uptake rate for engine room equipment, with around 2000 vessels equipped. While the use of EST propeller equipment, namely propeller ducts and rudder bulbs has also risen to 1,800 vessels and 1,300 vessels respectively, uptake for ESTs related to a vessel's deck equipment and hull has been slow so far. In terms of technology application, the use of ETS equipment is expected to depend on the type of ship. One key factor in this regard is technical compatibility. Several ETS products are not appropriate for low design speeds, which raises questions on the applicability for ship types such as tanker/dry bulk. Another factor to consider is commercial compatibility, for example, high capital expenditure (CAPEX) technologies are better suited for specialized, high-value assets, such as offshore support vessels, cruise ships or passenger ships (Lloyd's Register et al., 2015).

5.3. Digitalisation

74. In the past decade, the development of a number of digital technologies, often described as Industry 4.0, has started to transform businesses across sectors and industries. Despite a multiplicity of definitions and terms, the aim of these technologies is generally accepted to be the collection, exchange and processing of data to support an autonomous decision-making system. Key examples of Industry 4.0 technologies are Internet of Things (IoT), Big Data analytics, artificial intelligence (AI), robotics, cloud computing (CC), blockchain technology and additive manufacturing (Agarwala et al., 2021).

75. Recognizing the potential of digitalisation to optimise ship construction and operation and unlock opportunities for maritime decarbonisation, there is an increasing demand by customers for vessels to employ (more) digital marine equipment and technologies. The amount of data related to real-time tracking technologies has increased exponentially in recent years and nearly two-thirds of ships are nowadays using digital equipment for efficiency enhancement as well as improved commercial performance, navigation and

marine security (Mirović et al., 2018). Nonetheless, a lack of clarity relating to 'smart' or 'intelligent' products for ship design, construction and operation poses a significant challenge for the application of Industry 4.0 to marine equipment (Durkin, 2021).

76. While digitalisation has encouraged automation and the development of new 'intelligent' marine equipment products, the technology required is often less mature and commercially viable in the maritime industry than other industrial sectors. Proving the viability of new technologies to encourage their adoption is complicated by high costs and limited availability and sharing of data. In a study based on focus group responses and industry expert interviews, Sullivan et al. (2020) assess the level at which digital technologies are currently employed in the maritime sector and the level of integration between adopted technologies. They find that most digital technologies are considered to be at low maturity level for both design and construction of products, with "limited planning or operation" or "limited or intermediate operation". At the same time, stakeholders consider the development of new digital marine equipment an opportunity as developed digital technologies from other industries can potentially be applied to marine equipment products to achieve competitive advantages and foster decarbonisation.[7] Table 11 provides an overview of digital marine equipment products and their potential contribution to increasing a vessel's operational efficiency and reducing its GHG emissions.

Table 11. Overview of key digital marine technologies and their possible contribution for decarbonisation efforts

Digital Technology	Function	Decarbonisation Use
Big Data and AI	Use of sensors on the ship to transmit digital information to improve Machine Learning for a reliable Artificial Intelligence (AI)	Better analysis of various ship systems to optimise vessel and voyage operations and reduce fuel consumption
Digital twinning	Digital replica of the ship on shore permitting real-time monitoring of the ship and its machinery	Provision of predictive maintenance to the machinery to ensure an efficient ship with reduced GHG emissions
Internet of Things (IoT)	The control of machinery remotely by using machine to machine communication	Ship operation safer, less maintenance, downtime and fuel consumption
Blockchain digital ledger	Efficient movement of cargo from one port to another on ships to ensure faster loading and unloading operations	Increased efficiency of the vessel and less time in harbour resulting in reduced GHG emissions
Additive manufacturing/ 3D printing	Manufacture of machinery parts on the ship itself through digitised drawings of machinery	Reduction of spares on-board and easier reparation of defective machinery leading to more efficient operation

Source: Lloyd's Register et al. (2015) and Agarwala et al. (2021)

77. In the long-term, the "Global Marine Technology Trends 2030" report predicts the development of so-called 'Technomax' ships for bulk carriers, tankers, containerships and gas carriers. These would be 'smart' ships with the most advanced equipment for monitoring, supervising and manning the vessel and would often be semi- or fully autonomous ships using sensors and robotics technology to replace human operators (Lloyd's Register et al., 2015).

[7] The increased pressure by the IMO for operational energy efficiency has incentivised the maritime sector to apply digital technologies to a variety of decarbonisation efforts. Nonetheless, it is important to consider rebound effects, i.e. when anticipated savings from higher energy efficiency due to new equipment are only partially realized. This can be owed to greater utilisation of technologies and the higher electrical needs of digital equipment. Unless power is generated from green or low-carbon sources, higher electricity demand results in higher emission levels. Agarwala et al. (2021) estimate that GHG emissions reductions due to maritime digitalisation may be lessened by 10–30% due to rebound effects.

6. Policy framework

78. The three sections below present findings on government strategies (6.1), intellectual property rights and transfer of technology (6.2), and counterfeited and pirated goods (6.3).

79. To maximise synergies with the work conducted by other directorates within the OECD, the Secretariat used inputs from the work done by the Trade and Agriculture Directorate (TAD), the Economics Department (ECO), the Directorate for Public Governance (GOV), as well as the unit on Innovation Policies for Space and the Ocean within the Science, Technology and Innovation Directorate (STI).

6.1. Government strategies

80. This section discusses the main policies affecting the marine equipment industry in major marine equipment economies, notably updating information included in the *Report on Shipbuilding in China and Policies Affecting It*, which provided an in-depth analysis of policies implemented by the Chinese government in China's marine equipment sector (OECD, 2021b).

81. A significant number of the policies related to the maritime equipment industry involve programmes in the form of support for research and development (R&D). These include R&D support specifically targeted to the maritime equipment sector as well as broader horizontal frameworks for R&D support. Both horizontal and sectoral initiatives are covered, although the main focus in this section is on measures that specifically target the maritime equipment or shipbuilding sector. The analysis on R&D support may offer a bridge to the next section of the paper, as governments may want to protect the ownership of intangible assets resulting from government funding.

6.1.1. Japan

82. Japan indicated in response to the questionnaire sent by the Secretariat that the private sector may develop technologies by referring the vision set out by the government of Japan. For example, the "Green Growth Strategy Through Achieving Carbon Neutrality in 2050" , advances technology developments for carbon neutrality in the maritime equipment sector in order to contribute to carbon neutrality for shipping operators (Ministry of Economy, Trade and Industry, 2020).

83. According to Japan's Ministry of Economy, Trade and Industry (METI) (2020), this government strategy includes five cross sectoral policy tools (Grant funding, Tax incentives, Guidance policy on Finance, Regulatory reform and International collaboration) and action plans for 14 sectors. The government will establish a JPY 2 trillion fund to provide consistent support over the next 10 years to businesses that undertake innovations (Japan SPOTLIGHT, 2021). The shipping industry is one of the 14 sectors. The main future efforts for the shipping industry are as follows.

- Promoting technology development for the practical use of zero-emission ships.
- Developing frameworks to promote low-carbon ships.
- Promoting technology development improve energy efficiency of LNG-fueled ships.

6.1.2. Korea

84. Korea indicated in response to the questionnaire sent by the Secretariat that the Korean government is taking measures to support the marine equipment sector with various elements.

85. First, the Korean government provides support and funding to the R&D of marine equipment through government programmes with special attention for investments in the development of eco-friendly autonomous ships and other new technologies.

86. In addition, the government is continuing to strengthen the "Shipbuilding company-equipment material company-government win-win program". In this programme, the Korea Credit Guarantee Fund, the Technology Guarantee Fund and the Korea Trade Insurance Corporation provide necessary loans for marine equipment companies based on contributions from the shipbuilders and the government.

87. The Korean government also provides assistance in international cooperation of marine equipment companies for demonstration projects showing Korean equipment in overseas projects with the aim to support entry into overseas markets.

88. Korea announced the "Carbon Neutrality Vision and Strategy for Industry and Energy" in December 2021. According to the Ministry of Trade, Industry and Energy (2021), industrial R&D projects focused on carbon neutral technologies, environmental-friendly infrastructure, low-carbon materials, parts and equipment, and green engineering will be pushed ahead as well. Shipbuilding industry is one of the industries that needs to be transformed to low-carbon industrial structure. Expansion of new and renewable energy, conversion of ship propulsion fuel (expansion of eco-friendly ships), development of energy monitoring system specialized for shipbuilding process are the main efforts to achieve carbon neutrality in the shipbuilding industry.

6.1.3. European Union

89. The European Union is currently pursuing several maritime policies that, while not targeted directly at the European marine equipment sector, are expected to impact the industry. Under the overarching "Fit for 55" strategy, which aims to reduce the EU's GHG emissions by 55% by 2030 compared to 1990 levels, the EU has proposed the following policies to foster maritime decarbonisation (European Parliament, 2022):

    - *The inclusion of shipping in the EU-ETS for ships*: the EU-ETS is expected to include ships with tonnage over 5 000 GT and cover voyages between EU-ports and 50% of a voyage between an EU port and a non-EU port. At least 75% of the revenues generated by the allocation of emission credits are to be invested in a newly established Ocean Fund for maritime transport decarbonisation.
    - *FuelEU Maritime*: a new regulation on sustainable maritime fuels to introduce annual average targets for GHG intensity of energy used on ships.
    - *Energy taxation*: a revised directive on energy taxation with the aim of terminating tax exemptions for conventional marine fuels and incentivising the uptake of alternative fuels.
    - *Fuel infrastructure*: a revised directive on alternative fuels infrastructure with the aim of increasing availability of LNG by 2025 and shore-side electricity in main EU ports by 2030.

6.1.4. United Kingdom

90. The United Kingdom's Ministry of Defense has updated the National Shipbuilding Strategy in partnership with the recently formed National Shipbuilding Office (NSO). The government is planning to invest more than GBP 4 billion in new measures to rejuvenate the UK shipbuilding sector with the objective to deliver more than 150 new civil and naval vessels for the next 30 years (National Shipbuilding Office, 2022). Although the overall

growth of the shipbuilding industry is aimed, the action plans that are more relevant to the marine equipment industry are as follows:

- Enabling the commercialisation of critical shipbuilding technologies, particularly green technology by investing GBP 206 million to establish a UK Shipping Office for Reducing Emissions (UK-SHORE) in the Department for Transport (DfT).
- Supporting the shipbuilding sector to develop new technologies, including manufacturing and production technologies through UK Research and Innovation (UKRI) and Innovate UK programmes.
- Proactively pursue export opportunities through a coordinated approach with Government and industry, underpinned by the Maritime Capability Campaign Office (MCC)) within the Department for International Trade (DIT) which will act as the exports arm of the NSO.

6.1.5. China

91. The "Made in China 2025" plan, published by the Chinese government in 2015, serves as an overarching outline for its strategic objective to become a nation strong in high-end shipbuilding and offshore engineering equipment manufacturing. More detailed policies for China's shipbuilding and marine equipment sector are provided in the Five-Year Shipbuilding Action Plan (2016-2020) and the Boosting Capabilities of Marine Equipment Plan (2015-2020), issued by the Chinese Ministry of Industry and Information Technology (MIIT). Adhering to key principles of "innovation-driven", "deepened integration" and "structure optimisation", they formulated major objectives and framework measures, including a target of reaching a global market share of 34% to 40% in high-tech ships production by 2020 (Ministry of Industry and Information Technology, 2016).

92. The Boosting Capabilities of Marine Equipment Plan further aimed for 80% of the equipment used in Chinese newbuild bulk carriers, oil tankers, and container ships and 60% of the marine equipment deployed in Chinese newbuild high-tech ships to be produced by Chinese manufacturers by 2020. To achieve these objectives, the Plan outlined the following policies:

- The promotion of R&D Investment of marine equipment and establishment of necessary national development centres or national laboratories for marine equipment
- The mobilisation of different financial support measures as import taxes, newbuilding credit, development finance and insurance for the development of marine equipment
- The promotion of merging of activities to boost the capabilities and productivity of manufacturers in their production and marketing (OECD, 2021b).

93. In 2021, with the approval of the 14th Five-Year Plan (2021-2025), the Chinese government continued to prioritize high quality ships and marine engineering equipment. It proposed a plan to strengthen the competitiveness of the entire industrial chain in the shipbuilding sector and to promote R&D programmes focusing on cruise ships, LNG ships and deep-sea oil and gas production platforms. These policies include research initiatives on *inter alia* the promotion of LNG carriers (e.g. research on the design of LNG fuel storage and supply systems) and cruise ships (e.g. research on structural design technology and hydrodynamic performance of medium-sized luxury cruise ships). Research initiatives often constitute collaborations between universities (e.g. Shanghai Maritime University or Dalian Maritime University), the government and (state-owned) companies (e.g. Shanghai Electrical Apparatus Research Institute, the Shanghai Merchant Design and Research Institute or the Guangzhou Marine Engineering Corporation).

94. In most recent developments, five government agencies led by the Ministry of Industry and Information Technology (MIIT) issued a plan in October 2022 to significantly improve the level of 'smart' technology in marine equipment, as part of national efforts to develop a green and "smart" inland waterway shipbuilding industry. With intermediary goals for 2025, the aim is to foster digitalisation of equipment related to navigation, cargo loading, berthing and engine room equipment monitoring. The policy also aims to cultivate inland shipbuilding enterprises to develop low-carbon and digital ship design, equipment and construction (MERICS, 2022).

6.2. Intellectual property rights and transfer of technology

95. Intellectual property rights are an important aspect of the marine equipment industry. The specific design of a ship, the software used for energy optimization and ballast water treatment technologies can all be protected by intellectual property rights. The WTO's Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement sets the minimum standards for the protection of intellectual property rights. Based on its preamble, one can discern two important objectives of intellectual property protection. One the one hand, intellectual property rights can foster innovation. On the other hand, an overprotection of intellectual property rights could create an indirect trade barrier (WTO, 1994).

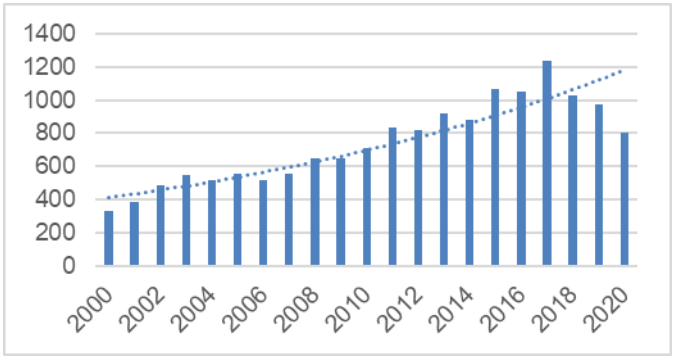
96. In addition and linked to the question of effective intellectual property protection, the section discusses a number of policies associated with the transfer of technology that affect the shipbuilding and marine equipment sectors. Given the potential confidential nature of some of the knowledge transferred, effective intellectual property protection will constitute an important prerequisite. If the level of intellectual property protection remains low or if the infringement of intellectual property rights is not enforced by the authorities, it will be harder to take action against an involuntary transfer of knowledge.

97. To acquire access to a foreign market, marine equipment suppliers may want to team up with a foreign entity in the form of a joint venture. Often these joint venture agreements include specific arrangements on the transfer of know-how. This knowledge transfer may be voluntary or not. The paper aims to set out a basic policy framework on transfer of technology practices, building on the methodology developed by the OECD Trade and Agriculture Directorate in its paper on International Technology Transfer Practices (OECD, 2019).

6.2.1. Patent analysis

98. Analysing patent trends in the marine equipment industry is helpful to understand the technical development in the sector. To conduct this patent analysis[8], the Secretariat used the Worldwide Patent Statistical Database (PATSTAT) maintained by the European Patent Office (EPO) that is included in the OECD STI Micro-data Lab infrastructure. First, over the past 20 years, the number of patent applications filed under the Patent Cooperation Treaty (PCT) for technologies related to marine equipment has been on the rise along with the growth of the shipbuilding industry. Figure 10 below illustrates the growth of patent applications in the marine equipment industry from 2000 to 2020. The number of patent applications increased from around 300 per year in the early 2000s, reaching 700 per year in 2010, and reached 1,200 per year in 2017. Although it has been decreasing since 2017, the overall trend over the past 20 years is oriented upward. With the development of high value-added ships, the shipbuilding industry is gradually transforming into a technology-intensive industry as shown by the upward trend in patent applications. Given the continuous technological development, it is expected that the number of patent applications in the marine equipment industry will continue to increase in the future.

Figure 10. PCT patents in marine equipment-related technologies, 2000-2020



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, November 2022.

99. PCT patent applications in the marine equipment industry are led by large shipbuilding companies, as shown in Table 12 below. The top 10 companies are based in Japan, Korea, China and Germany, which are the countries with strengths in the shipbuilding industry. Daewoo shipbuilding & Marine engineering and Samsung heavy industries are also in the top 10 patent applicants and in the top 10 shipbuilding companies in terms of order book as of November 2022.

[8] Based on the International Patent Classification (IPC), B63B, B63C, B63G, B63H and B63J were applied for the technical fields to analyze the patents used in the marine equipment industry.

B63		SHIPS OR OTHER WATERBORNE VESSELS; RELATED EQUIPMENT
	B63B	SHIPS OR OTHER WATERBORNE VESSELS; EQUIPMENT FOR SHIPPING (arrangements of vessel ventilation, heating, cooling, or air-conditioning B63J 2/00; floating substructures as supports of dredgers or soil-shifting machines E02F 9/06)
	B63C	LAUNCHING, HAULING-OUT, OR DRY-DOCKING OF VESSELS; LIFE-SAVING IN WATER; EQUIPMENT FOR DWELLING OR WORKING UNDER WATER; MEANS FOR SALVAGING OR SEARCHING FOR UNDERWATER OBJECTS (floating nets, floating slipways, or the like for recovering aircraft from the water B63B 35/52)
	B63G	OFFENSIVE OR DEFENSIVE ARRANGEMENTS ON VESSELS; MINE-LAYING; MINE-SWEEPING; SUBMARINES; AIRCRAFT CARRIERS (means of attack or defence in general, e.g. turrets, F41H)
	B63H	MARINE PROPULSION OR STEERING (propulsion of air-cushion vehicles B60V 1/14; specially adapted for submarines, other than nuclear propulsion, B63G; specially adapted for torpedoes F42B 19/00)
	B63J	AUXILIARIES ON VESSELS

Source : International Patent Classification (IPC) (wipo.int)

Table 12. Top 10 applicants in marine equipment-related technologies, 2011-2020[9]

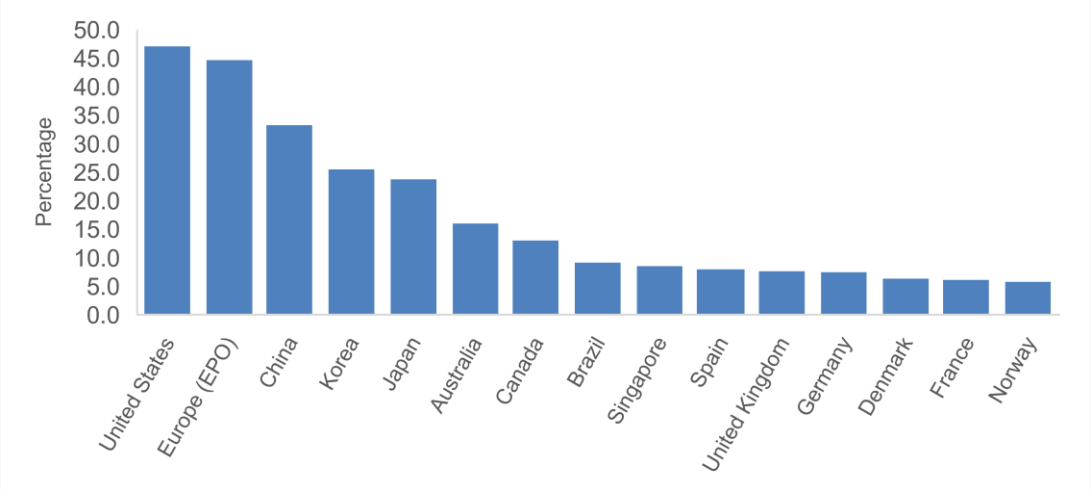
#	Applicants	Origin	PCT Patent Applications
1	MITSUBISHI HEAVY IND LTD	JP	159
2	DAEWOO SHIPBUILDING&MARINE ENG CO LTD	KR	135
3	KAWASAKI JUKOGYO CO LTD	JP	125
4	GUANGZHOU SHIPYARD INT CO LTD	CN	109
5	THYSSENKRUPP AG	DE	99
6	THYSSENKRUPP MARINE SYSTEMS GMBH	DE	96
7	SIEMENS AG	DE	88
8	SAMSUNG HEAVY IND CO LTD	KR	73
9	MITSUI ENG & SHIPBUILDING CO LTD	JP	68
10	KR INSTITUTE OF OCEAN SCIENCE & TECH	KR	60

Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, November 2022.

100. According to the EPO, countries with a high level of patent applications are potentially interesting markets for the exploitation of the corresponding technologies. Experience indeed suggests that patent protection is very often sought in countries in which the commercial prospects are good enough to outweigh the costs and the visibility implied by patent and utility model protection. Figure 11 below shows the share of PCT patents entering regional or national phase in total PCT applications. As shown, the United States, the European Union, China, Korea and Japan are the economies which are leaders in terms of patent applications related to the marine equipment industry.

Figure 11. Top 15 economies protecting marine equipment-related technologies, 2011-2020

Share in patent applications



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, November 2022.
Note: Data refer to the IP offices where PCT patent applications in marine equipment-related technologies were extended

[9] Sea Europe pointed out that estimations on shipyards representing 7 out of 10 biggest players for marine equipment might the exaggerated and recommended ensuring that equipment is not related to defence.

6.2.2. Intellectual property rights (IPR) dispute[10]

101. Intellectual property rights (IPR) disputes appear to be less frequent in the marine equipment industry and the shipbuilding industry compared to other manufacturing industries. This is mainly due to the fact that the shipbuilding industry uses custom-made manufacturing methods. It is more difficult to follow a standardised production process than in other manufacturing sector, and the size, function, and shape of ships as well as marine equipment used in ships change according to the needs of shipowners.

102. More specifically, and above all, shipowners decide on most materials, parts, and systems used in the ships. Moreover, blueprints and data used by ships belong to the owners and not the shipyards. This is to facilitate repairs after construction and delivery. Intellectual property rights are also included in the ship price.

103. Secondly, according to Paris Convention for the Protection of Industry Property, when a ship enters the waters of Union's country, no infringement of patent rights can be claimed for the equipment in the vessel. This Convention which aims to facilitate the operations of vessels makes it much harder to challenge IPR infringement.

104. Thirdly, even if intellectual property infringement has occurred, legal disputes are relatively rare. Usually, the compensation of the infringement occurs by paying royalties after negotiations between the parties.

105. Patent disputes often arise at times when technology changes significantly, such as fuel conversion. A recent case of patent dispute occurred in the process of switching from diesel engine ships to LNG ships among Korean shipbuilders in the mid-2010s. The dispute was about the partial re-liquefaction technology used to re-liquefy naturally vaporized boil-off gas (BOG) in an LNG carrier. Daewoo Shipbuilding & Marine Engineering Co. (DSME) appeared to have benefited from its patent on the partial re-liquefaction technology helping DSME outperform its competitors in winning orders to build LNG carriers. However, competitors argued that the technology had been widely used among other shipbuilders in the industry and that the patent held by DSME should be nullified. Hyundai Heavy Industries and Samsung Heavy Industries launched a patent invalidation battle against DSME to the Intellectual Property Trial and Appeal Board in 2014 and 2015, respectively, after DSME registered the patent on the partial re-liquefaction in January 2014. In 2017, the Supreme Court rejected an appeal raised by DSME to review the Patent Court's January rule in favour of Hyundai Heavy Industries and Samsung Heavy Industries that had sought to make DSME's patent on partial re-liquefaction technology invalid. Following the court's final decision, DSME would not be allowed to promote the partial re-liquefaction technology as its proprietary technology when selling its LNG vessels (Moon, 2017).

6.3. Counterfeited and pirated goods

106. As ships are global assets, their repair and maintenance work can take place in different regions in the world. In order not to affect a ship's schedule, ship-owners may prefer to purchase a component provided by a local supplier in a foreign port. The authenticity of these parts can, however, not always be verified.

107. Indeed, very little is known about the scale of counterfeited or pirated marine equipment. The importance of mapping the size of counterfeited and pirated marine equipment not only stems from the impact that they have on the profits of original equipment manufacturers (OEMs), but also from the consequences in case a fake component breaks

[10] Statistics such as the number of IPR disputes in the marine equipment industry are rare, so this sub-section was prepared used after on the basis of some experts' opinions.

down. Such a breakdown may namely lead to expensive repairs and delays in the vessel's schedule and could hamper a vessel's safety. For governments, counterfeited and pirated goods may mean a loss of tax revenues, loss of employment and greater compliance and enforcement costs.

108. Subsequently, this paper intends to map some of the potential technologies that may simplify the identification of fake products in the next version of this paper. One example may be the use of distributed ledger technologies in combination with the Internet of Things . Another example may be to install an electronic tagging system.

7. Policy recommendations

109. *Improving patent management*: With the growth of the shipbuilding industry over the past 20 years and an increase of R&D investment for securing technologies of future ships, global patent applications in the marine equipment sector have been increasing and are expected to continue growing in the future. Governments, companies and research institutes should investigate patent trends at the early stage, before technologies are deployed, to improve patent management and avoid duplicating technologies.

110. *Ensuring intellectual property rights*: The development of new technologies necessitates the right instruments to protect them. The risk of infringement of intellectual property rights, such as counterfeited and pirated goods, often derives from the leakage of work force and data. Accordingly, measures should be put in place not only to train technical manpower in the marine equipment industry but also to prevent illegal leakage of technologies and sensitive data.

111. *Optimising supply chain management*: To support the improvement of supply and inter-organisational business processes, government policies should encourage the use of information technologies for marine supply chain applications. The adoption of information technologies should help the collection and analysis of data on shipyards and equipment suppliers' operations to better identify and address weaknesses in the supply chain.

112. *Channeling R&D for decarbonisation*: Fostering innovation to make low-carbon technologies competitive with their high-carbon alternatives should be a key objective of decarbonisation policies. To promote eco-friendly ships and low-carbon marine equipment, government support to business R&D should play an important role in securing core technologies for more carbon-efficient and eco-friendly ships. Government policies should provide adequate, targeted and closely monitored R&D support that reduces technology costs and encourages innovation in low-carbon technologies while not impairing fair competition in the market.

113. *New skills for new technologies*: As technologies are developing with increasing speed and interdependencies, the linkages between marine technological systems and skilled labour are becoming more complex and impose demands on the skills of workers designing, manufacturing and operating marine equipment products. Measures to train a skilled-labour force and develop human and institutional capacities (especially in emerging market economies) must coincide with digitalisation and decarbonisation efforts, to maximise the benefits from new digital technologies, find workable solutions and achieve a just and people-centered transition.

8. Conclusion

114. This report describes the marine equipment industry, its recent market developments and ongoing trends as well as policies affecting it.

115. The market part of this report discusses various market trends including changes in global value chains (GVC), decarbonisation and digitalisation. The expansion of GVCs and the acceleration for the eco-friendly and smart ships are noticeable aspects in the recent marine equipment sector. Furthermore, the policy part discusses government strategies, intellectual property rights and technology transfer in the marine equipment industry. With the increase of investment for securing technology of future ships, policy issues such as managing patent, training workforce and preventing the leakage of technology become agendas to pay attention to.

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ANNEX: inputs received following the questionnaire

Intellectual Property rights

Korea

116. Korean shipbuilding and marine equipment companies prevent the transfer or leakage of core technologies through the issuance of patents, etc. Korean companies transfer the information, intellectual property they can provide to joint venture partners.

Sea Europe

117. Business cooperation in the maritime technology industry can bring benefits for cooperating companies and encourage innovation. However, a common understanding on the principles and functioning of intellectual property rights is key and a precondition for any business or research cooperation. This requires reciprocity in the protection and respect to each other's Intellectual Property Rights and reciprocal obligations.

118. China provides an important case in this respect. The Report of the European Commission on protection and enforcement of IPR in third countries (2020) acknowledges that the poor protection and enforcement of intellectual property rights (IPR) in China continues to be a major concern for EU companies and criticised the "scale and persistence" of unsolved problems in the Chinese system. Moreover, the report mentions that despite visible progress and attempts to reform, China's low level of protection for trade secrets and IP theft is still causing "irreparable harm to European businesses".

119. The European Commission's report on protection and enforcement of IPR in third countries (2020) warns that forced technology transfer – by which European companies are obliged to share their technologies to do business in China – is a "systemic problem". The Study says that an "increasingly important trade irritant is China's objective to absorb foreign technology and make it Chinese ('re-innovate'), particularly in key technological areas defined by the state, such as through the Made in China 2025 strategy". This can be expected to impact the shipbuilding and marine equipment sector since they are included as priority targets and "key technological areas" in several national strategies

120. The policy tools employed to reach this objective are manifold. Chinese government and state-owned companies pressure foreign firms to transfer technology to China in exchange for market access, investment access or regulatory approvals. Apparently, foreign companies are also forced to license technology below market rates, as a pre-condition to access and to operate in certain markets.

121. Shipbuilding and maritime technology companies are also affected by the weak IPR protection and enforcement mechanisms in China and other countries.

122. In its 2019-2020 Position Paper on Shipbuilding, the EU-China Chamber of Commerce warns that the draft Catalogue on Encouraging Foreign Investment Industries, published in 2019 by Chinese authorities is a clear example of how government policies are used to encourage forms of technology transfers aimed at advancing the competitiveness of the domestic industry. The catalogue encourages foreign investments in activities related to designing and projecting ships and ships components, whereas production is openly excluded. Hence, it appears that the government's intent is to encourage foreign companies to share their knowhow and best practices, while leaving to their Chinese counterparts the economic and industrial benefits related to selling and producing. Such technology transfers are induced or forced through policy guidance, legal instruments and practices, including through joint venture requirements/equity caps,

authorisation or licensing procedures, or insufficient protection of intellectual property rights and trade secrets.

Counterfeiting and pirated goods

Korea

118. Since most of the domestic shipbuilding and marine equipment industries are composed of small and medium-sized enterprises, security vulnerabilities are greater than those of large enterprises are. There is always a risk of infringement of intellectual property rights due to the leakage of work force and data. As the proportion of IT in corporate operations has increased recently, the risk and diversity of technology leakage such as hacking through the Internet is increasing. There are cases involving the manufacturing and selling of illegal copies due to the leakage of design drawings and research personnel.

119. Counterfeited and pirated goods depend on complex factors that conflict the interests of stakeholders such as shipping, shipbuilding, and shipbuilding equipment, and various situations such as cost reduction in the shipping industry through compatible products, profits from exclusive sales of large engine makers and equipment companies, and equipment companies.

120. In order to accurately grasp the current status of illegal copying products, related investigations and analysis must be preceded to identify the market size and situation of illegal products to come up with a solution. It is necessary for each country to seek sanctions through revision of related laws.

Japan

121. Japan indicated that in a ship where Port State Control was carried out, a counterfeited product of a fuel injector valve of the engine was found in November 2020.

122. Japan added that here is no official data on the size of the problem (as for IPR infringement and forced technology transfer). Since counterfeited and pirated products are likely to threaten the safety navigation and environment protection, some measures are taken such as public relations to users (ex. shipping operators) on using genuine products or labeling of genuine products.

SEA Europe

123. European maritime equipment and technology providers are global leaders in developing the most advanced and innovative assets. The volume of counterfeiting in the industry, the specific challenges to monitor and control the use of non-original pieces of equipment and spare parts due to the nature of the maritime business and the impact that the use of these products can have compromising maritime safety and the environment require a close look to the problem.

124. Establishing framework conditions to reduce the use of counterfeited maritime products is of utmost importance to ensure the safety and environmental performance of all maritime operations but also to support innovators and manufacturers in protecting their competitiveness and intellectual property.

125. Main categories of pirated and counterfeited goods: Counterfeited maritime equipment and components can be divided in two types of products:

- Counterfeited pieces of equipment or systems and high volume of spare parts that are used for the after-market, for the maintenance and replacement of parts during the life of the ship or piece of equipment. Some examples are:

  - Seals of various types and materials. Mainly dynamic seals in different types of elastomers, but also static seals that need replacement when changing dynamic seals.
  - Further, re-engineered mechanical parts that are subject to operational wear
  - Other simpler electrical components and products
  - Engine spare parts like cylinder valves, main bearings, connecting rod bearings,
  - fuel injection equipment, pistons, cylinder liners, piston rings and cylinder covers.
  - Inert Gas Systems
  - Exhaust Gas Cleaning Systems (EGCS)
  - Control systems
  - Safety equipment

- Businesses also experience pure copying of their product descriptions, as well as copying of their products, mainly in Asia.

126. The volume of counterfeited and pirated spare parts in the global market could be as high as 20% of the total spare parts. Based on analysis of market shares and spare parts quotation hit rate, the volume of the grey market for spare parts would be of €1 billion.

127. The economic harm for their individual businesses can amount hundreds of millions per year. A medium-sized company provided an estimated impact in the after marker of 2 to 4 million EUR per year.

128. In the case of Exhaust Gas Control Systems at least 50% of the turnover is counterfeited of which 80% is reported to be in China.

129. The use of OEM (original equipment manufacturer) components and equipment is not only crucial for meeting regulatory requirements, but also one of the corner stones for maintaining asset integrity in the age of digital transformation.

130. For instance, the IMO (International Maritime Organization) in its International Safety Management Code (ISM Code) outlines in Sections 1, 8 and 10 the requirements for emergency preparedness on board vessels. The identification of safety critical equipment and use/storage of safety critical spare parts for main and auxiliary engines on board vessels can be considered as one of those safeguards.

131. Notably, the International Association of Classification Societies (IACS), the principal technical advisor of IMO, lists and recommends the afore mentioned components and equipment listed in Item 1 above for ensuring emergency preparedness on board vessels.

132. In line with that, the “failure rate” of equipment and spare parts manufacturers are monitored by classification societies, owners, credit unions, underwriters and public administrations.

133. European maritime equipment and technology manufacturers are obliged and committed to ensure the highest quality and reliability of their products through Approved Documentation, Approved Makers and Approved Repair company audits and certifications. However, about 28% of all vessel inspections criticise missing or insufficient documentation, meaning that one out of 4 inspections has documentation claims.

134. 42% of Hull and Machinery claims are related to machinery failures, 48% of those being related to engine failures, 25% to auxiliary engines, 7% to thrusters and 5% to propellers. The use of counterfeited equipment and even spare parts used for maintenance and replacement of onboard equipment, bought from unauthorised suppliers suppose a high risk to the performance of the machinery and the ship and could lead to failures compromising the environment and the safety of the ship, the crew and the environment.

For instance, the use of counterfeited dynamic seal systems do pose an increased risk of environmental damage.

135. The use of counterfeited products can also generate corrosion issues, giving a bad reputation to the original providers. Besides this, if the owner or the respective authorities are not aware of the use of counterfeited spare parts and equipment, the claims for liabilities and incident statistics can be unfairly reported to the equipment maker.

136. At this moment in time, we are not aware of any public policy to impede the production and commercialisation of counterfeited substandard products by non-authorised companies.

137. Monitoring the use of counterfeited products gets very difficult given that ships keep sailing and moving. On top of this, an additional difficulty for enforcing the intellectual property and fight against patent infringements and counterfeiting is the exemption contained in Article 5ter of Paris Convention for the Protection of Industrial Property, related to "Patented Devices Forming Part of Vessel, Aircraft, or Land Vehicles". This article states that it "shall not be considered as infringements of the rights of a patentee the use on board vessels of other countries of the Union of devices forming the subject of his patent in the body of the vessel, in the machinery, tackle, gear and other accessories, when such vessels temporarily or accidentally enter the waters of the said country, provided that such devices are used there exclusively for the needs of the vessel".

In practical terms it is almost impossible for an OEM or a shipyard to enforce their IPR when a vessel is carrying counterfeited equipment or parts installed onboard or contains any part infringing a patent, while the vessel is part of an international trade lane. This "limbo" is benefiting the proliferation of counterfeited and pirated products and patent infringements in the maritime business across the globe.