Foresight in Civil Shipbuilding — 2030

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Foresight studies of future markets and technologies enable various scenarios for the shipbuilding industry to be identified.

Innovative scenarios assume a shift from mass production to small-scale or even single-unit niche production under diversified demand. This should be accompanied by active promotion of competition not only in shipbuilding but in related industries too.

Comparative analysis of scenarios shows that active government policies to support the production of high-technology vessels will generate multiplier effects and strengthen the competitiveness of the Russian economy.

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Shipbuilding is an economic sector that has high scientific, technological and production potential and is capable of generating a significant impact on the development of technology in related industries. As a result, key maritime states around the world pay particular attention to the creation and development of innovative technologies in the shipbuilding industry.

Foresight has confirmed its effectiveness as a long-term forecasting instrument for scientific, technological and economic development in the industry as it allows analysts to take into account a complex array of factors influencing market supply and demand alongside current technological trends [*Georghiou et al*, 2008; *Gokhberg, Sokolov*, 2013; *Saritas et al*, 2013; *Haegeman et al*, 2013]. This article seeks to outline the future of the shipbuilding industry in the period up to 2030 based on an assessment of the current state of the global and domestic shipbuilding and ship repair markets and a forecast of changes with account of contextual factors.

The prospects for scientific and technological development in the domestic civil shipbuilding and ship repair industries have been viewed in the context of global, national and inter-industry challenges, trends, driving forces and constraints. This study of inter-industry interaction has enabled us to highlight the synergetic effects brought about by the application of technological innovations from other economic industries.

Methodology

In technology forecasting practice technology-oriented (technology push) and market-oriented (market pull) approaches are typically adopted. While the first derives from an analysis of research developments with some potential for practical application and innovative technologies and high-tech products and services based on these developments [*Kim et al*, 2009; *Lee et al*, 2007; *Lichtenthaler*, 2008], the second is focused on studying the factors linked to demand for innovative products and certain technologies used in their production [*Albright, Kappel*, 2003; *Daim, Oliver*, 2008; *Holmes, Ferrill*, 2005; *Lee et al*, 2009]. Foresight studies in any sector of the economy presuppose a synthesis of these approaches, combining the scope for application of prospective products with their production opportunities, which in turn is heavily dependent on the results of scientific research and development (R&D). This is of particular importance for high-tech industries, the specific nature of which directly shapes the mechanism to couple supply with demand [*Dodgson*, 2000; *Wells et al*, 2004; *Karasev, Vishnevskiy*, 2013; *Caetano, Amaral*, 2011]. It is primarily a question of the high value of scientific and technological offerings (human, material, technical, information and financial resources) and the weak predictability of future demand for R&D and new technologies: its segments, dynamics, volume, etc.

The combination of methods used to analyse the development of high-tech sectors of the economy has enabled us to give a comprehensive assessment of factors affecting the scientific, technological, production and market potential of specific innovative products in the civil shipbuilding industry and to formulate substantiated recommendations on a system of priorities for each link of the technological chain. A large group of experts has been involved in the study, selected on the basis of strict qualifying criteria. Among them are members of the research community, industry, government bodies and foreign specialists from leading nations in the shipbuilding industry.

During the five stages of the Foresight study (Table 1), the potential competitiveness of certain groups of innovative products was assessed from a demand perspective, and segments and clusters of innovative technologies were identified. To this end, a knowledge base was created after classifying and sorting the conclusions drawn by many specialist studies on innovative development in the shipbuilding industry and related sectors, including various strategies, programmes and forecasts developed in Russia and abroad [Minpromtorg, 2013; European Commission, 2012; European Commission, 2009; Marine Institute, 2006; Norwegian Agency for Development Cooperation, 2010; *Boelens et al*, 2005; *Giovacchini, Sersic*, 2012; and others].

Table 1. **Stages of the Foresight study into the development of the shipbuilding industry**

Stages	Description
1	Creation of the knowledge base: more than 90 Russian and foreign sources of various types were analysed.
2	Analysis of the current state of and trends in the development of the global shipbuilding industry: • discussion of current developmental trends in the shipbuilding industry in Russia and abroad; • study of external environmental factors shaping economic demand for various shipbuilding products; • outline of the inherent challenges facing the industry.
3	Study of the factors affecting future demand for innovative products: • description of the typical groups of consumers in each segment; • analysis of the developmental prospects of existing demand segments; • identification of potential niches in the market; • discussion of factors affecting changes in long-term demand and the potential to satisfy demand through innovation.
4	Identification of technological priorities and opportunities in the Russian shipbuilding industry • analysis of the potential competitiveness of certain groups of innovative products in the identified demand segments; • discussion of the risks, barriers and constraints of innovative development; • SWOT-analysis of the strengths (S) and weaknesses (W) of manufacturers in the shipbuilding industry and their potential development opportunities (O) and threats (T); • drawing up a list of prospective technologies and products.
5	Modelling of alternative developmental trajectories in the domestic shipbuilding industry using a scenario method: • discussion of key factors of uncertainty and forks (bifurcation points) where changes in trajectory could occur; • development of possible industry development scenarios; • definition of characteristics and conditions for the realisation of these scenarios; • formulation of expected results.

Source: HSE ISSEK.

Any substantiated forecast of developmental prospects in the shipbuilding industry will be based on external environmental influences, including global trends in social and economic development. Since the industry is heavily dependent on global phenomena such as the environment, energy, demography, food, transport and technological change, one of the key sources shaping the future of the shipbuilding industry which forms the basis for this analysis is the concept of 'grand challenges' [European Commission, 2010a; European Commission, 2010b]. These relate to, among other things, urbanisation, labour migration and changes to the population age structure (ageing). Major global trends include the spread of electrical data transfer networks, the increasing significance of bio-, micro- and nano-technologies, the rapid growth of the intellectual services sector, and the growing influence of international organisations, etc. The response to these factors must come from forward-looking developments and the implementation of new technologies and products to satisfy our rapidly changing needs. Challenges that are negative (threats) and positive (opportunities) are already manifesting themselves today. They serve as harbingers of future large-scale shifts in the shipbuilding industry, set national and industry-specific trends and predetermine priorities for scientific, technological and innovative development.

The high degree of uncertainty defines the long-term prospects for innovative development. Therefore, for the purposes of our study, different variants of the developmental course in the civil shipbuilding industry have been explored using a scenario-based method. During the modelling of these alternative trajectories, we have taken into account, above all, uncertainty factors and forks (bifurcation points) where changes in trajectory could take place [*Ogilvy*, 2002; *Godet*, 2001; *Kennedy et al*, 2003]. Based on the results of the study, possible scenarios for the development of the shipbuilding industry have been identified, together with their characteristics and the conditions for their realisation, the attendant challenges and risks, as well as the results which are achievable in the long-term under the 'scenario' priorities system.

There is extensive global experience in the elaboration of scenarios for the development of the shipbuilding industry. In this regard, the study Global Scenarios of Shipping in 2030 [Wartsila, 2010][1] proposes three potential scenarios for the period up to 2030: 'Rough Seas, 'Yellow River' and 'Open Oceans, all developed taking into account changes in external factors. According to the first of these scenarios, limited resources and growth in social and inter-ethnic tension are cited as key factors in the development of the shipbuilding industry. The second scenario proposes the emer-

[1] This study was carried out by the Finnish company Wartsila, a company specialising in the production of ship propulsion systems, power plants, propeller mechanisms, ship guidance systems and other equipment.

gence of China as a global and economic leader, including in the shipbuilding industry. In the third scenario, global corporations govern the global economy. To study external factors, the influence on the future of the shipbuilding industry is presented in the useful 2006 study of alternative scenarios for the future of the maritime ecosystem by the British Centre for Environment, Fisheries and Aquaculture Science. The report examines the varying development of certain segments of the shipbuilding industry using wild card events (events which are extremely unlikely to occur but could have a radical change in the external environment) [*Pinnegar et al*, 2006].

This Foresight study and the developmental scenarios of the domestic shipbuilding industry created as a result of the research have enabled us to identify certain priorities for the innovative process, to express the coherence of these findings and to uncover certain correlations. We selected integral prospective fields in the shipbuilding industry that have the potential to complete the entire innovative cycle — from R&D to commercialisation of the end product. Based on the scenarios, we have formulated certain intrinsic challenges facing the industry: positive — new opportunities to implement innovative products; and negative — fixing the 'bottlenecks' in the innovation system and identifying the attendant risks, constraints and barriers.

The global shipbuilding industry: key trends and global challenges

According to surveyed experts, a decisive factor in the current state of the global shipbuilding market is the overproduction crisis and the steady rise in capacity backed by domestic demand from manufacturing nations. The capacity of traditional exporters therefore remains unused. Changes in the markets, including at local level, for freight traffic, labour, and certain product types (oil, timber and others) play a significant role in this.

Today, there are approximately 560 shipyards around the world capable of building a ship within one year with a total tonnage of 55–60 million CGT (compensated gross tonnage).[2] However, there is a core of around 166 shipyards which provide 85% of the global shipbuilding industry's output (in 2011, their workload did not exceed 85%). To assess annual workforce productivity, the ratio of the combined tonnage of the ships produced in one year (in CGT) to the number of employees working at the shipyard is taken into account. Thus, in Japan this figure is approximately 180 CGT per person, South Korea — 145, Germany — 75, the remaining EU countries — 40, and in Russia only 20 CGT per person [Minpromtorg, 2013].

The changing development of global shipping suggests a transformation in its structure. Over recent years the specific weight and tonnage of bulk shipping has changed significantly around the world, largely due to heavy-tonnage ships. In the period 2009–2013, the proportion of bulk shipping (by deadweight tonnage) around the world increased from 37% to 44%, while the specific weight of tanker shipping reduced from 31% to 28%. At the same time, the proportion of ships used to transport liquid chemicals and liquefied gases and special dry-cargo ships rose, while the specific weight of general dry-cargo and traditional refrigerator vessels fell.

Positive trends in the development of global shipping are being buoyed by encouraging shifts in international trade. Nevertheless, data on global maritime transport and changes in cargo shipping for 2010–2011 confirm a persistent imbalance between supply and demand on freight markets.

An analysis of the regional structure of the global shipbuilding and repair market as well as the specific advantages of leading international companies has identified the success factors of certain leading nations in the sector (Fig. 1).

As we can see from Figure 1, European companies, traditionally seen as occupying strong positions on high-tech product markets, have considerably lost

[2] An indicator of the amount of work required to build a ship. Calculated by multiplying the carrying capacity of the ship by a coefficient determined according to the ship's specific type and size.

Figure 1. **Results of a SWOT analysis of the leading players on the shipbuilding market**

South Korea		Japan	
Strengths	**Weaknesses**	**Strengths**	**Weaknesses**
• qualified workforce • economies of scale • developed extractive industry • high buyer confidence • developed, high quality shipbuilding technologies • high labour productivity • short production cycle	• insufficiently developed inland shipping • high workforce costs • low business diversification • insufficient development of the financial market • lack of base technologies in the cruise ship and sea facilities segments	• high level of innovative activity • presence of a large number of small- and medium-sized innovative businesses • high quality of sea equipment • stable links between shipyards and ship equipment manufacturers • stable employment conditions • specialisation in niche markets	• high expenditure (including wages and steel prices) • potential difficulties protecting knowledge (in particular among small- and medium-sized businesses) • shortage of qualified specialists
Opportunities	**Threats**	**Opportunities**	**Threats**
• low raw material prices • depreciation of the Korean currency	• growth in the Chinese economy and consolidation of its position on the shipbuilding industry • instability on the global shipbuilding market • low demand for shipbuilding products • surplus output	• continuous innovation • environmental awareness of the shipbuilding industry • active transport policy (environmentally-friendly transport, improved transport services quality) • increased transport standards requirements	• intensification of marine clusters • consolidation of competitors' positions on the market • lack of workforce and ageing workforce • price-based competition in the light of the economic crisis
China		**European Union**	
Strengths	**Weaknesses**	**Strengths**	**Weaknesses**
• low labour costs • sufficient steel supplies • significant government support	• insufficient development of shipbuilding design and technologies • lack of production of key components in the country	• highly-qualified workforce • high level of technological development of the shipbuilding industry • government support and protectionism • high labour productivity	• high production costs • dominance of internal orders over external
Opportunities	**Threats**	**Opportunities**	**Threats**
• growth in demand for sea and river transport to ship iron ore, coal, grain, construction materials and other bulk freight	• lack of qualified specialists • fluctuations in national currency exchange rates • surplus output • fall in productivity	• development of competitive advantages	• loss of position on the market due to lower production costs among competitors • collapse in global prices

Source: HSE ISSEK.

their competitive advantages due to high production costs. On the contrary, strong state support and cooperation with Japanese and South Korean companies have allowed China to quickly take a leading position. The success of Korean manufacturers is down to developed infrastructure, high quality products and the professionalism of their engineering and technical staff. Small business innovation and niche specialisation have allowed Japan to hold on to a significant market share which, however, is gradually shrinking under the pressure of high production costs. However, all leading nations in the shipbuilding industry are now engaging in large-scale R&D investment.

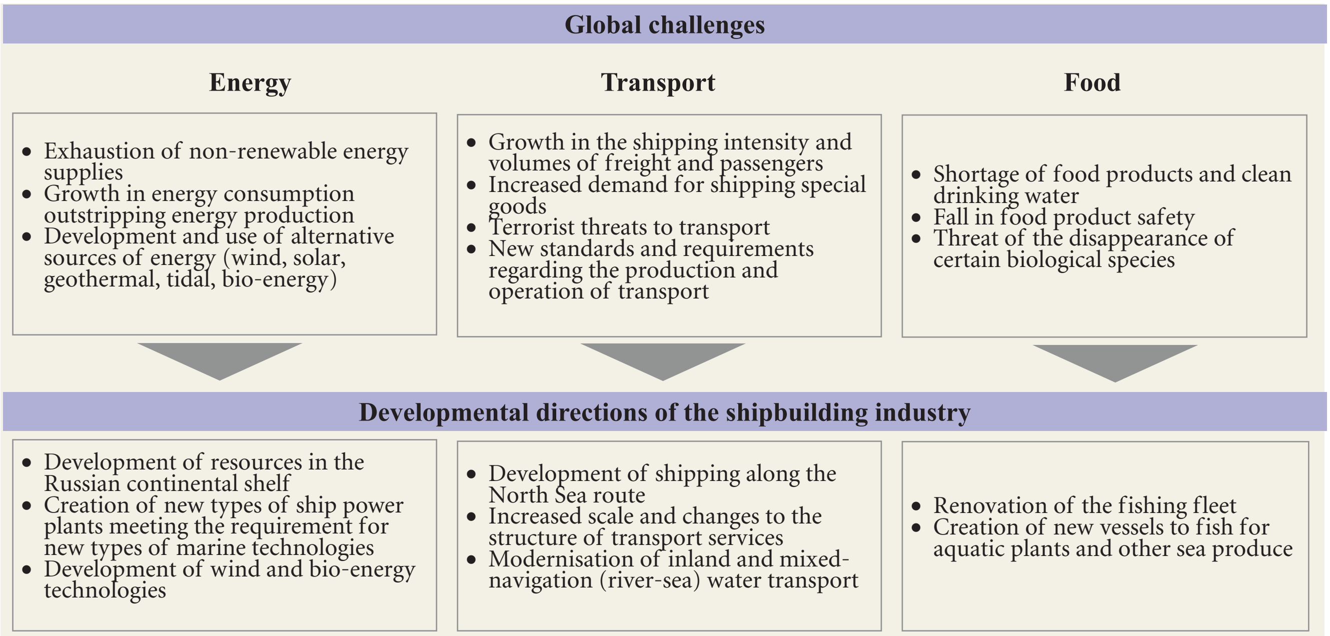
Global challenges

An important stage of this study was the analysis of global challenges in various industries (energy, transport, food, etc.) Together, these challenges define the prospective directions of the shipbuilding industry. Thus, the gradual exhaustion of traditional non-renewable sources of energy calls for active development of resources in the continental shelf; the intensity and volume of freight transport attach considerable importance to the development of shipping along the North Sea routes; and the shortage of food products and clean drinking water is giving rise to a resurgence in fishing fleet activity (Fig. 2).

Technological priorities

National Foresight studies together with the strategies of leading Russian and foreign shipbuilding companies allow an overview of the innovative technologies and high-tech products which manufacturers consider to be their priorities to be compiled and compared with the challenges and driving forces behind innovative development and inter-industry interaction (technology push).

Figure 2. **The development of the shipbuilding industry as a response to global challenges**



Source: HSE ISSEK.

Over 400 technologies and products were consolidated into 11 groups (thematic industries):

- ecology and environmental protection;
- engines and mechanisms;
- ship construction;
- new materials and processing technologies;
- information technology and automated systems;
- navigation and telecommunications;
- energy and energy saving;
- safety and security;
- steering and control;
- ship life cycle technologies;
- production technologies.

Despite the discrepancy in technological priorities across countries, in the future the shipbuilding industry will call for new production technologies and improved ship, engine, machinery and mechanism designs (Fig. 3).

It is clear from Figure 3 that the strategic interests of Japanese companies are concentrated around new types of ship engines and mechanisms, energy-saving technologies, new materials and improved environmental credentials of products in the industry. China's priorities are primarily linked to new production technologies, ship designs and safety. Korean specialists expressed an heightened interest in information technologies and automated systems.

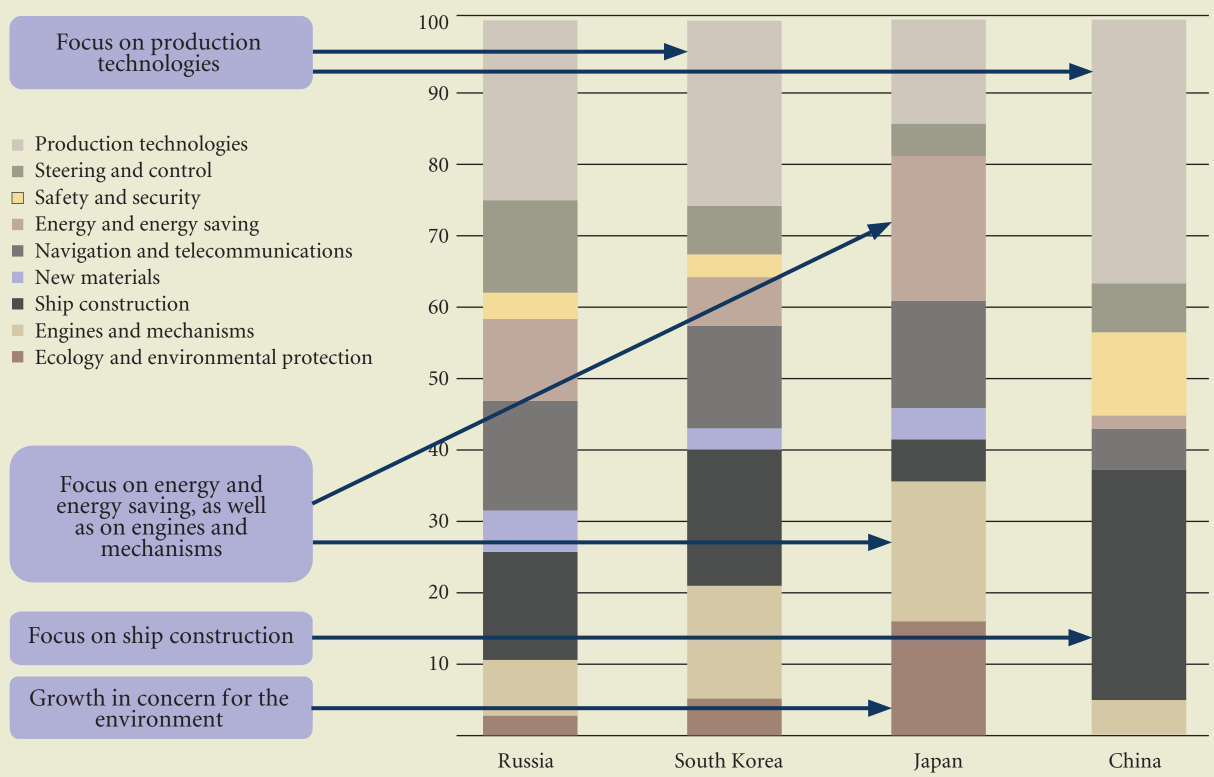
The Russian shipbuilding industry: opportunities

Historically, a significant proportion of domestic machinery, electronics and devices for ships have been developed and produced within Russia. The industry has more than 200 businesses working on maritime and river technology, building and repairing ships with displacements of up to five thousand tonnes [Minpromtorg, 2013]. Shipbuilders collaborate with more than 2000 businesses supplying component end products used in the production process. In this regard, shipbuilders are one of the main domestic consumers of metal products which makes the metal working industry dependent on the outlook of the Russian shipbuilding industry.

Maritime cargo shipping

The Russian economy needs steady growth in freight turnover from waterborne transport — both maritime and inland. The proportion of Russian ex-

Figure 3. **National technological priorities** (*percentage of total number of technologies*)



Source: HSE ISSEK. based on national Foresight study material

port/import cargo as a percentage of global maritime cargo transportation in 2011 was approximately 6%. However, with control over almost 1,400 vessels with a total dead-weight of 19.6 million tonnes (1,067 vessels with a dead-weight of 5.2 million tonnes flying the Russian flag and 351 vessels with a dead-weight of 14.4 million tonnes — or approximately 75% — flying a foreign flag), Russia's share of the global shipping industry is 1.56%, which is about 16th or 17th in the world rankings. Based on the capacity of ships flying the national flag, Russia's share is 1.61% (27th globally). The average age of Russian vessels is 22.9 years, whereas for foreign ships it is 8.2 [Minpromtorg, 2013].

Achieving 50% of Russian foreign trade cargo operations using domestic transport (at present, it is approximately 6% for maritime transport) and 100% through national terminal capacity (currently about 80%) is a strategic objective.

Experts predict that in future, the transportation of products from Russian hydrocarbon deposits will increase significantly. This will be primarily in the Arctic shelf and in the coastal region, and new directions will be identified for the development of traditional ('conventional') shipping.

Inland water-borne transport

10–15% of freight shipments and approximately 5% of passenger journeys in Russia take place using inland water-borne transport. Russia's key advantage lies in low costs, but the main problem is the seasonality of operations. In the past decade, inland water-borne routes have been used with growing intensity. In 2010–2012 there was a surge in demand from Russian shipping companies for inland and mixed navigation cargo vessels, however, the opportunities for manufacturers held back growth in shipments.

Russian water-borne passenger (cruise) transport is characterised by above-average wear and tear and obsolescence. The age of the majority of vessels built almost exclusively abroad (in Germany, Czechoslovakia, Austria and other countries) is 40–50 years. With the advent of high-speed new ships based on a dynamic means of keeping afloat (hydrofoils and hovercraft) Russia had significant technological advantages and has to a considerable extent maintained this potential to the present day. High-speed passenger shipping could play a significant role in solving the issue of transport accessibility, a relatively critical problem facing many regions across the country. This segment of the market is of little interest to foreign shipbuilders, which opens up greater prospects for their Russian colleagues. High volumes and off-the-shelf solutions serve as security for effective technological solutions in the industry and productive inter-plant collaboration to manufacture components.

According to expert assessments, in the next 8–10 years the combined order portfolio for inland water-borne transport vessels could exceed 100 billion roubles. Engineers, producers and those operating inland and mixed navigation ships face the following scientific and technical issues:

- maximising the load-bearing capacity of ships amid constraints on their berthing;
- extending freight navigation during the spring and autumn with acceptable costs (new technologies to break initial ice forms and highly fractured ice);
- developing inland water-borne logistics.

Equipment to develop the continental shelf

Sea-based shelf deposit technologies have been in development since the start of the 20th century. In the second half of the century, various classes of maritime structures appeared to enable oil and gas extraction, and by the early 1980s, there were three groups of off-shore technologies: drilling platforms, production platforms and supply vessels.

Today, the ocean shelf supports approximately 50% of global hydrocarbon extraction. At the same time, shallow continental and coastal deposits are nearing depletion, which increases the importance of deep deposits (2,000–3,000 m) hundreds of kilometres away from the coastline.

Changes to natural and climate conditions lead to new demands of maritime oil and gas extraction facilities. While the first sea-based facilities were situated in the Caspian Sea and the Persian Gulf, and later across the Gulf of Mexico and the North and Norwegian seas, future international projects are looking to develop deposits in the Barents and Kara seas.

Vast mineral supplies, chiefly raw hydrocarbons, can be found in the Russian continental shelf. The largest and most promising portion of these supplies is concentrated in the seas and on the coast of the Arctic Ocean where the extreme natural and climatic conditions (primarily, ice) is unprecedented. The experience of Russian companies working on the Sakhalin Island, North Caspian and Barents Sea shelves is clearly not adequate. The poorly developed coastal infrastructure and special environmental demands on companies operating in the region create further difficulties when developing the Arctic deposits. In addition, we cannot count on importing technology. Foreign oil and gas extraction and operating companies involved in Russian continental shelf projects have shown their inability to independently work on the designs of sea-based technical facilities and to implement a work cycle to prepare deposits for working in icy conditions.

These problems call for the design and implementation of entirely new Russian sea technologies: innovative technological solutions to use in underwater icy conditions. Innovations are required both in terms of the extraction and liquefaction of gas in small volumes and the shipment and transportation of the extracted raw material (for example, Shell's pilot project Prelude on the Australian continental shelf to extract, liquefy and ship by sea 3.6 million tonnes of gas per year).

Technological developments are essential both to convert gas into methanol, then to shift the technology platform to a new footing, as well as to devise alternative ways to transport it (in gas-hydrate form or compressed). The required innovations described entail increased safety demands regarding the transportation of hydrocarbons: the combustion heat of liquefied gas transported by a 150,000 m^3 methane carrier vessel reaches the equivalent of 100 kt of TNT, which is 5–6 times greater than the energy yield of the atom bomb dropped on Hiroshima.

The significant advantages of developing the promising Russian continental shelf may well result in the use of certain new technological solutions. First, this would involve the production of synthetic fuel from gas based on Fischer-Tropsch synthesis, which, according to specialists, will comes to be advantageous once a certain price has been reached for hydrocarbons. In this regard, Shell built a plant to produce synthetic fuel in Qatar in 2007. Then in 2011, several companies started to develop Compact GTL equipment enabling them to produce synthetic fuel on a sea-based platform directly at the gas extraction site. Experts also commend this potential use of underwater vessels for prospecting and underwater extraction facilities to develop deposits in regions with difficult icy conditions.

The evidence presented in this section leads us to suggest two trends linked to the development of the continental shelf which could have the greatest impact on the Russian shipbuilding industry in the next 20–30 years:

- growth in the processing depth of formation products from sea-based platforms followed by ship transportation to demand regions;
- gradual transition to fully integrated underwater (under ice) technologies to develop shelf deposits — from prospecting to processing.

Commercial shipping

Support for Russian commercial shipping comes from the need to guarantee the food security of the country. Unfortunately, over the last 15 years there has been a steady ageing and reduction in the size of vessel fleets in the industry.

The Russian fishing fleet is made up of approximately 2,000 ships with various purposes. More than 80% of them are operated beyond their standard service life. They are not only ineffective, but also do not meet modern safety standards. To meet the required fish and seafood catches, the maximum service life of vessels is forever increasing.

By 2020, the number of vessels could shrink by almost two-fold relative to the current level, with this mainly affecting medium- and high-tonnage vessels the most. In addition, the country's objective demand for commercial ships in the period up to 2025 is valued at approximately 180 large and medium and at least 220 small vessels of various profiles, making a total worth in excess of 170 billion roubles. A significant proportion of domestic demand for civil shipbuilding can be satisfied by Russian shipbuilders.

The key priorities for industry members are:

- to develop their scientific and technological stock to manufacture highly cost-effective, competitive ships;
- to modernise and build commercial, auxiliary and transport vessels, and special equipment to extract and process water-based bio-resources;
- to improve the financial and economic conditions surrounding the construction and lease of ships, in particular, by subsidising loan and lease payment interest rates;
- to reduce the price of ships;
- to transfer and implement foreign civil shipbuilding technologies.

Modernising commercial shipping will make it possible to broaden the food base through maximising the effective use of sea bio-resources. While currently the bulk of catches are in the economic zone in the seas around Russia, long-term there needs to be renewed expeditionary fishing in distant regions of the ocean, requiring the development and construction of appropriate vessels.

Potential market niches

The potential for development in the shipbuilding industry is linked to the choice of priority market niches to sell products. These market segments must show high demand for various classes of vessels with diverse functional purposes, but they must also respond to certain consumer demands (*market pull*).

The shipbuilding market is traditionally divided into five segments:

- passenger and freight transport;
- extraction and processing of sea-based bio-resources;
- scientific research;
- development and working of mineral deposits;
- technical and support work and services.

Each segment is influenced by the macro-economic factors described above. Thus, GDP growth, increases in global trading, steel production, higher labour productivity in the industry, and other factors all have a positive effect on these segments. In contrast, factors such as rising fuel and steel prices, and currency risks can have a negative impact on the situation in certain market niches in the shipbuilding industry.

The Russian shipbuilding industry faces three priority challenges, which will shape the course of its development over the coming decades:

- effective development of the North Sea route;
- effective and environmentally friendly development of Pacific Ocean resources, primarily bio-resources and hydrocarbons on the Russian continental shelf (with a full life cycle involving prospecting, extraction, and transportation of raw materials and finished products to regions where demand is);
- expansion of the transport network – guaranteeing access to inland waterways for freight and passenger vessels and extending the navigation season.

The solution to these tasks presupposes the development and construction of ships and maritime equipment which are capable of operating under difficult icy conditions on inland waterways, along the North Sea shipping routes, and in regions where the Arctic shelf is being developed. These are still essentially unoccupied niches on the global shipbuilding market, free from the presence (competition) of foreign companies. The range of such vessels and maritime equipment could include, but is not limited to, drilling and operating platforms, shipping terminals, various types of ships to extract hydrocarbons, ice-breakers, tugboats, ships with a high ice class (including tankers and gas carriers), scientific research vessels (to study the oil and gas potential of the continental shelf, provide hydrometeorological support, and monitor the environment), and environmental safety vessels.

All the ships and water-borne facilities listed above are some of the most high-tech and knowledge-intensive products in the shipbuilding industry. Russian research and design-and-engineering organisations had a significant lead in this field, one which is only poorly exploited in practice. In the worst case scenario, the existing competitive advantages could be lost irretrievably amid increased efforts from many foreign shipbuilding companies seeking involvement in projects linked to the development of the Russian Arctic.

Taking into account the current production structure and technological organisation of the domestic shipbuilding industry, fully securing these niches for Russian companies not only satisfies the country's production potential, but also the current objectives of the national economy. The achievement of this goal is one step along the path towards the creation of new production output capable of producing high-tonnage Arctic navigation vessels and large sea platforms.

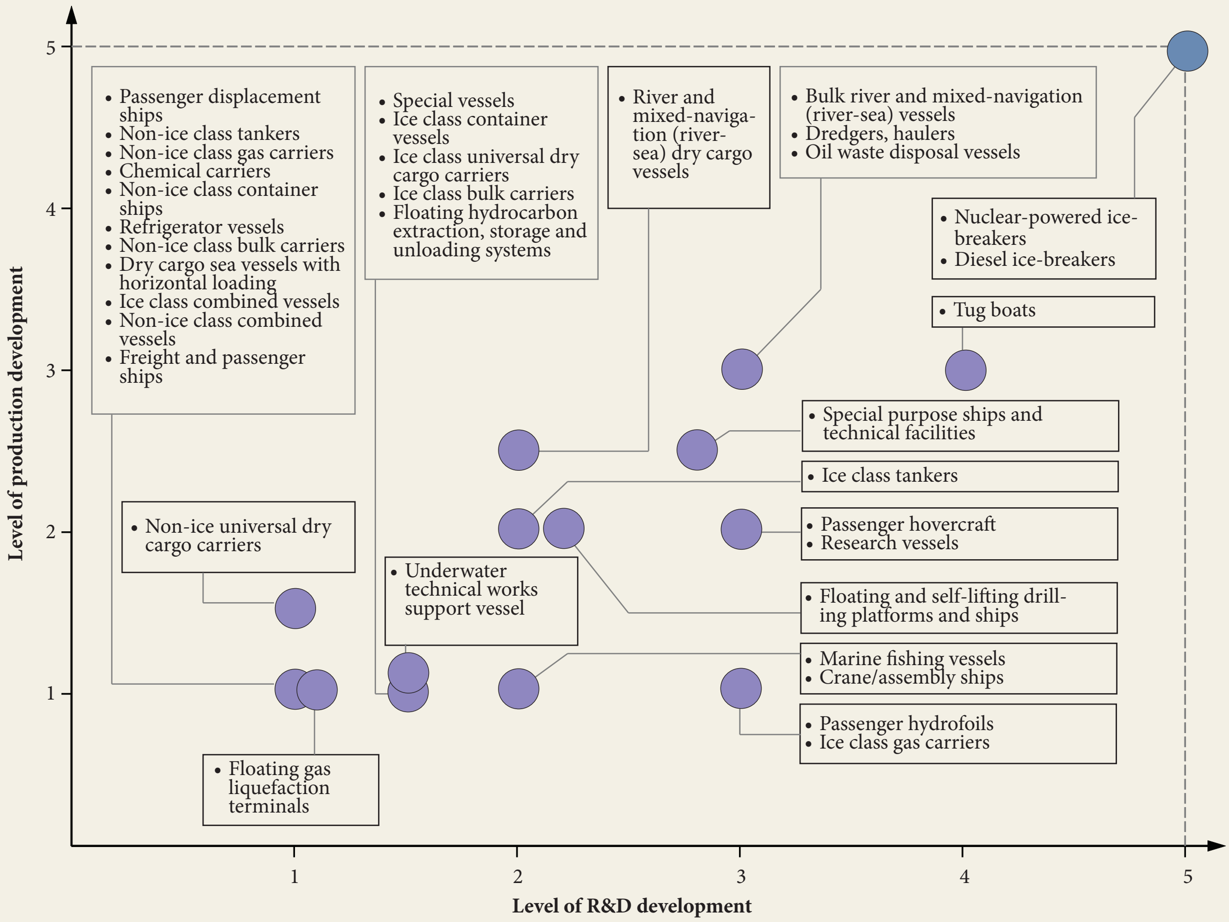
Based on experts' assessments, we carried out an analysis of the market potential of products from the Russian shipbuilding industry (Fig. 4).

Barriers, risks and opportunities

Objectively, the long production cycle and colossal capital-output ratio of production in civil shipbuilding cause high levels of concentration and significant barriers to entry. These are problems not only for manufacturers, but also consumers who are faced with high prices for products and unfavourable lending conditions, which, in turn, make the customer dependent on the financial infrastructure. The credit term is five years at best, covers a maximum of 60% of the cost of the ship, and rates are several times higher than abroad. One of the consequences of this situation is the lack of competition between buyers: attracting investment on the global financial markets to place an order for ships is only possible for the very largest ship owning companies. Moreover, the lending terms are less attractive than they are for their global competitors, who are able to take advantage of favourable financial conditions and governmental support in their own countries.

Focusing on niche products would place the Russian shipbuilding industry in a new competitive environment and allow the industry to transition from batch production with strict pricing policies to filling highly specialised orders. Local market niche players would no longer have to engage in direct and harsh competitive struggles. However, breaking onto new markets is not possible without corresponding legislation and the introduction of effective economic mechanisms; the absence of

Figure 4. **Level of competitiveness of certain types of shipbuilding products***



* Calculated on the basis of a survey of exports, using ratings on a scale from 1 to 5:

1 — significantly below foreign standards;
2 — slightly below foreign standards;
3 — on a par with similar foreign products;
4 — slightly above foreign standards;
5 — significantly above foreign standards.

Source: HSE ISSEK.

these factors would expose companies to serious additional risks which, briefly, include:

1. The displacement of civil shipbuilding from the global and Russian market, leading both to direct budgetary losses and to further dependence on foreign carriers with their increasing presence in the North Sea shipping zone and their penetration into the inland river network;
2. International legal disputes over the development of Arctic hydrocarbon deposits;
3. The possible reduction in state support for the shipbuilding industry and weakened protectionism due to the Russian Federation joining the WTO;
4. The shortage of qualified workers in the industry;
5. The worsening financial and economic position of consumers, the change in consumer priorities, and the configuration of the entire sales market in the industry;
6. A reduction in potential investor activity in the face of an unfavourable investment climate;
7. Complications in the financial position of developers and manufacturers of shipbuilding products, etc.

To assess the dynamics of the shipbuilding industry and determine its growth areas, we carried out a SWOT analysis showing the range of opportunities for development in the industry and the internal and external obstacles (Fig. 5).

The challenges currently facing today's shipbuilding industry are systemic in nature. Some of them can partly be solved on a federal level with the help of industry-wide programmes. However, to achieve the set targets, such measures are not enough insofar as the construction of innovative vessels requires equipment and materials produced by associated sectors of the industry. There needs to be an entire complex of integrated solutions that aims to harmonise the activities of all companies manufacturing the sea and river technologies required in the near and distant future.

Innovative development scenarios in the Russian shipbuilding industry

By analysing the current situation of the Russian shipbuilding market, we have been able to identify the main challenges facing the industry and affecting its future development:

- the structural disparity of the shipbuilding industry;
- the reduced competitiveness of Russian products on the global market;
- imperfect legislation and financial infrastructure;
- the need for state support.

To build the scenario matrix, experts chose two critical factors to plot the developmental course of the civil shipbuilding industry in Russia: innovative activity against the development of the national economy. In the method we adopted, each of these factors was assigned two values: low or high 'innovative activity' and unfavourable or favourable 'development of the national economy.' The combination of these values and factors allowed four potential scenarios for the development of the industry to be identified (Fig. 6).

The inertial scenarios for the development of the shipbuilding industry (1a, 1b) result from the failure to adopt measures that aim to eliminate the barriers to the industry's development and ignore the possible risks. The pessimistic inertial sce-

Figure 5. **SWOT analysis of the domestic shipbuilding industry**

Strengths

- Low cost price of inland water transport journeys
- Partial retention of technological potential since the days of the USSR
- Presence of government industry development programmes
- Presence of technologies to develop sea-based shelf deposits

Key market development reserves are linked to the development and creation of ships and marine technologies for operation in the Arctic region

Opportunities

- Growth in water transport freight turnover
- Expansion of shipping into the Spring and Autumn
- Solving the problem of poor access in certain territories across the country using high-speed passenger vessels
- Emergence of new segments of demand for shipbuilding products
- Development of international transport corridor systems
- Development of recreation zones in seaside cities
- Development of tourism and growth in demand for river travel
- Development of technologies to work shelf deposits
- Development of high-speed water transport
- Growth in business investment in ocean research and development of marine biotechnologies
- Development of new resource-saving technologies and technologies to process water bio-resources
- Development of new trade regions and facilities
- Development of targeted programmes and strategies on a national and international level geared towards developing the industry (including programmes to develop bio-technologies)
- Implementation of projects to improve sea bio-resource extraction and processing quality

Weaknesses

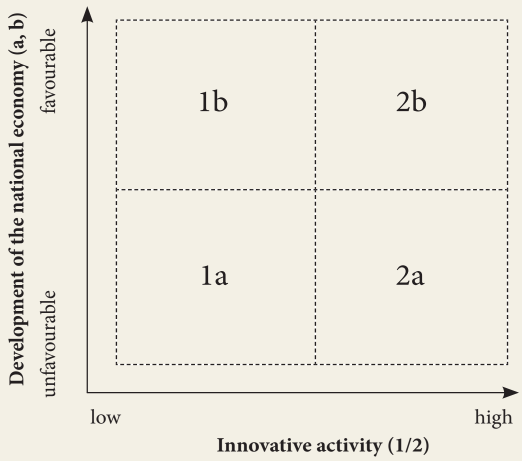
- Inadequate funding
- Technological backwardness in the civil shipbuilding industry
- Low production efficiency, labour productivity, product competitiveness
- Low rate of renewal of key production resources
- Lack of qualified personnel
- Low profitability on Arctic deposits
- Lack of competition in labour conditions compared with other economic sectors
- Depreciation of inland waterway infrastructure
- Lag behind modern international standards regarding a number of ship environmental parameters
- High cost of ship construction, lack of investor incentives
- Long repair times or servicing for transport vehicles
- Lack of domestic technological base in several areas, lack of development of the element base, insufficient quality of domestic construction and expendable materials
- High cost of prototyping when developing transport vehicles
- Lack of production output to build transport vessels with a deadweight of over 70-80 thousand tonnes (full displacement over 100,000 tonnes)
- Lack of financial and tax incentives for shipbuilding businesses

Threats

- Expected financial crises and economic instability
- Sharp fall in defence R&D in the 1990s-2000s
- Ageing regulatory framework for ship design
- Improvement in competitors' positions on the market

Source: HSE ISSEK.

Figure 6. **Scenario matrix for the development of the Russian shipbuilding industry**



Source: HSE ISSEK.

nario (1a) assumes an unstable economic situation in Russia and globally, a lack of funding opportunities for long-term projects, an overall drop in production levels and, as a result, a fall in demand for sea transport. The optimistic inertial scenario (1b) is characterised by a favourable economic situation in Russia, good conditions on the hydrocarbons market, an improved investment climate and resulting growth in investment in ship production and shipyard construction. However, the absence of any required changes in the legislative framework and the continuing poor financial infrastructure in the scenario hold back the forecast growth rates of the industry and hinder the solution of its structural problems.

The innovative scenarios (2a, 2b) assume full implementation of state support programmes for the shipbuilding industry, sufficient funding for R&D, as well as gradual changes to the production structure, increasing the proportion of commercial output.

The combination of characteristics from each of these scenarios affects the future outlook of the industry as a whole (Table 2).

Inertial scenarios

According to the *pessimistic inertial scenario*, not a single modern shipyard will be built in Russia, and the introduction of innovative technologies into the shipbuilding industry will be put off. The lack of investment in R&D into new production and ship operation methods has particularly acute consequences.

The main demand segments for domestic shipbuilding products under this developmental model of events comes from freight traffic (river- and mixed-navigation) and the extraction and processing of marine bio-resources. In addition, non-self-propelled and self-propelled water-borne facilities will be in demand to operate on inland waterways and high-speed vessels.

Under the *optimistic inertial scenario*, as noted above, we can expect a fall in production growth rates and an intensification of structural imbalances. The continuation of the existing funding principles for the shipbuilding industry will place Russian manufacturers in a poor situation compared with global competitors. A substantial chunk of funds goes on purchasing equipment using imported components without any comparable products in Russia.

The development of the industry along one of these scenarios will follow demand from consumers in market segments such as freight shipping, the extraction and processing of marine bio-resources, and the development and working of Arctic mineral deposits. There will be demand for small high-speed vessels, ships for inland waterways and sophisticated commercial ships (research vessels, ice-breakers, support and technical ships). 70-80% of demand for inland water transport may be satisfied, whereas only 50-60% of demand for sophisticated commercial ships is likely to be.

Table 2. **Characteristics of development scenarios for the shipbuilding industry in Russia**

Characteristics	Development scenarios			
	Inertial		Innovative	
	pessimistic	optimistic	pessimistic	optimistic
Ratio of commercial to military production	Predominance of military production and defence orders	Predominance of military production and defence orders	Balance between commercial and military production in total industry output	Balance between commercial and military production in total industry output
Competitiveness of production	Low	Average	Average	High
Legislative framework	Poor legislative framework, propensity for corruption, legal barriers to business development	Poor legislative framework, propensity for corruption	Elimination of legislative defects	Elimination of legislative defects
State policy in the shipbuilding industry	Curtailment or suspension of state programmes	Partial curtailment or suspension of state programmes	Continuation of state programmes	Continuation of state programmes
Financial infrastructure	Weak	Weak	Existence of funding and lending mechanisms	Existence of funding and lending mechanisms
Global trade and GDP	Fall	Rise	Fall	Rise
Oil price	50 US dollars/barrel	from 100 US dollars/ barrel	50 US dollars/barrel	from 100 US dollars/ barrel

Source: HSE ISSEK.

The inertial scenarios are fraught with a number of negative consequences for the Russian shipbuilding industry, including:

- the loss of some of the most important technologies, which could significantly complicate the implementation of the government programme in the shipbuilding industry;
- a reduction in the number of ships built due to increases in production costs and time;
- loss of position on the global shipbuilding market.

Table 3 shows the likely changes in the industry under inertial developmental models.

Innovative scenarios

The pessimistic innovative scenario presupposes active government support for the shipbuilding industry and the formation of effective financial infrastructure. These conditions will make it possible to construct a modern shipyard to build commercial vessels with a fall in economic indicators and some deficit in financial resources. It will give rise to prerequisites to transition onto an innovative developmental path for the industry using modern technologies. In particular, there is forecast to be an expansion in the number of relevant research projects.

Under this scenario, there will be demand for a wider range of products than in previous variants in market segments such as freight shipping, the extraction and processing of marine bio-resources, the development and working of Arctic deposits,

Table 3. **Key shipbuilding indicators under inertial scenarios**

	2012	Pessimistic			Optimistic		
		2015	2020	2030	2015	2020	2030
Production volume *(billions of roubles)*	90	200	160	100	250	180	100
Share of the global military shipbuilding market (%)	12	11	10	< 10	12	13	14
Share of the civil shipbuilding market (%)	0.4	0.3	0.3	0.4	0.5	1	2
Construction of inland water-borne transport (share of required level, %)	4	30	30–40	30–40	30–40	50	70
Construction of sophisticated commercial ships (share of required level, %)	0.5	2–3	5–7	10	5–10	20–30	50–60
Share of Russian foreign trade cargo base shipped by Russian transport (by sea-based transport, %)	6	6	6	6	7	8	10

Source: HSE ISSEK.

Table 4. **Key innovative scenario indicators for shipbuilding industry development**

	2012	Pessimistic			Optimistic		
		2015	2020	2030	2015	2020	2030
Production volume (*billions of rubles*)	90	350	500	650	350	500	700
Share of the global military equipment market (%)	12	12	14	15	12	15	> 15
Share of the global commercial equipment market (%)	0.3	0.5	1	1.5	0.6	1.5	2.5
Construction of inland water-borne transport (share of required level, %)	4	10–20	30–40	70–80	10–20	40–50	100
Construction of sophisticated commercial ships (share of required level, %)	≈ 0.5	10–15	30–35	70–75	10–20	40–50	100
Construction of large sea platforms (share of required level, %)	≈ 0.5	5–10	20–30	40– 50	5–10	20–30	50–60
Construction of high-tonnage maritime ships (share of required level, %)	≈ 0.5	1–2	5–10	10–20	5–10	20–30	40–50
Share of Russian foreign trade cargo base shipped by Russian transport (by sea-based transport, %)	6	15	20–30	50	15	30	50

Source: HSE ISSEK.

scientific research, and technical and support work and services. It is expected that Russian manufacturers will succeed in satisfying 70%–80% of demand for inland waterway vessels. As for the construction of sophisticated commercial vessels (research ships, ice-breakers, platform supply vessels, support and technical ships), this figure will reach 100% of the required volume, for sea platforms the same figure will be around 40%–50%, and for high-tonnage vessels — 10%–20%.

The optimistic innovative scenario assumes an effective government policy under favourable economic conditions, propelling the Russian shipbuilding industry into a new round of development, increasing its investment appeal and improving its technological infrastructure. Such a turn of events would enable the industry to construct several modern shipyards to build commercial vessels, intensively introduce innovative technologies during production, and increase R&D. Exports of commercial vessels could reach 600–800 million US dollars per year, with export figures for military ships around 2.3–3.0 billion US dollars.

Instead of supporting the construction of an entire range of ships, the optimistic innovative scenario envisages pinpoint initiatives for small-scale or even single-unit niche production. It calls on existing horizontally integrated structures to be re-organised into clusters for niche production to act as drivers of growth in the industry.

The transition to an innovative scenario requires active support for competition in associated industries in the form of clusters. The multiplier effects generated by the production of high-tech special-purpose ships will consolidate the competitive position of companies at all points of the production chain. Manufacturers can direct their attention towards various demand segments — passenger (river) and freight shipping, the extraction and processing of marine bio-resources, the development and working of Arctic deposits, scientific research, and technical and support work. Demand for inland water transport, in particular, and for sophisticated sea vessels will be met in full; demand for sea platforms with innovative processing and drilling technologies will be satisfied at the level of 50%–60%; for sea shipping vessels, only 40%–50% of demand will be met. This means that 2%–2.5% of the global civil shipbuilding market can be gained.

Likely indicators for the development of the shipbuilding industry with its transition to an innovative developmental path are shown in Table 4.

The realisation of these innovative scenarios will lead to the development of not only domestic competition by involving highly competitive types of activity in shipbuilding clusters, but also to foreign competition thanks to the Russian shipbuilding industry's shift to monopolistic (rather than price-based) competition where it has, or could have, clear advantages. Unlike in the inertial scenarios, state investment would be targeted only at areas where financing from the state is of utmost necessity (notably, to areas of growth for a future cluster hub).

Conclusion

As a result of applying Foresight methods in our study, we have identified the priority objectives facing the shipbuilding industry. Finding solutions to certain challenges will reduce the negative impact of global factors and make it possible to harness the competitive advantages of the domestic shipbuilding industry; advantages which can be gained by realising both existing and new opportunities globally. The analysis of global trends and the discussion of sector-specific priorities for the Russian shipbuilding industry have allowed us to present a prospective product line taking into account the external challenges that may have an effect on consumption structure and consumer preferences.

An assessment of the factors shaping the scientific, technological, production and market potential of specific innovative products could be beneficial when elaborating a set of substantiated recommendations linked to a detailed system of priorities at each stage of the technological chain. Our analysis showed that in leading shipbuilding nations of the world a substantial proportion of R&D is aimed at developing production technologies and improving ship, engine, equipment and machinery designs.

The comparison of the possible developmental scenarios for the shipbuilding industry for the period up to 2030, taking into account the parameters and impact of these scenarios, showed that the production of high-tech vessels against the backdrop of active government policy in the civil shipbuilding industry (the innovative scenario) will give rise to multiplier effects and will consolidate the competitiveness of the Russian economy. F

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