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Classification of Risks of High-Technology Production

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Abstract
In the modern economic system, the concept of developing high-technology production shapes the competitiveness and outlook of national economic development. The specifics of high-technology production imply considerable risks emerging across the lifecycle, which requires risk management. The paper explores the aspects of businesses engaged in high-technology production and the risks involved. A classification of risks is proposed for high-technology production in accordance with the requirements set in standard GOST R ISO 9001-2015.

Key-words: High-technology Production, Risks, Risk Management, Quality Management System, Classification.

1. Introduction

The transition from a commodity-driven toward an innovation-led economy depends on multiple conditions, specifically determined by government policies in the area of science and technology.

Advanced production is characterised by the high content of underlying R&D and theoretical insights.

It is a relevant research and practical task to analyse the theoretical aspects of risk management in the context of high-technology production.

The mechanism of risk management is based on the concept of risk-based thinking set forth in standards GOST R ISO 9001-2015 [1] and GOST R ISO 31000-2010 [2], ISO 31000:2018 [3], as well as the principles of process-based management approach. The framework of risk-based thinking refers to managerial decision-making guided by risk analysis. Therefore, risk management in the management system should not be the organisation's goal and objective as it is but should be an instrument to achieve these goals [4].

With that, alongside the analysis of the essence, main characteristics, and functions of risks, it is also crucial to classify risks and their causes.

Risk classifications are used to develop management systems, scales for risk measurement; analytical procedures are performed and sets of measures are implemented to maintain risks within the tolerable maximum level.

The approach is specifically relevant for high-technology production.

2. Methods and Criteria for Categorising High-technology Products

High-technology products include products, works, and services meeting the following set of criteria:

- The products should be included in the list of priorities of scientific, technological, and technical development of Russia [5];
- The products are manufactured to advanced technologies using modern equipment and with the engagement of high-skilled talent;
- The content of R&D costs in total costs or sales is at least 3.5–4.5%.
- The share of high-skilled talent engaged in manufacturing is in line with global standards.

All the above factors in aggregate define the notion of "research intensity." The research intensity of a business determines not only its level of scientific and technological development but also the degree of novelty in what it produces [6].

The category of research-intensive products comprises products with research content levels of at least 3.5%. Where the content of research costs is above 8.5%, such production represents the high technology type; for medium-high technology, the level of research content is 2.5%, for low technology, 0.5%

Globally, two of the most authoritative classifications of high technology industries are used, namely, the classification of the Organisation of Economic Cooperation and Development (OECD) [7] and the classification of the United Nations Industrial Development Organization (UNIDO) [8].

The classification of the UNIDO included input from the OECD, meanwhile, it opts for a division into three groups of industries: low technology, medium technology; high technology. Based on this division, medium-technology industries are also included in the high-technology sector.

According to the OECD methodology, industries where the content of sectoral research costs in the shipped product costs is above 5% are part of the high-technology sector. Industries with the content of R&D costs within 2.5 to 5% represent the medium-high-technology sector; those within the range between 1 to 2.5% belong to the medium-low-technology sector; and those with the share below 1%, to the low-technology sector [7].

Table 1 outlines a classification of industries by the level of technology according to the OECD.

Table 1- Classification of Industries of High-technology Production According to the OECD

Categories of industries	**Industries**
High-technology industries	Aircraft and spacecraft
	Pharmaceuticals
	Office, accounting and computing machinery
	Radio, TV and communications equipment
	Medical, precision and optical instruments
Medium-high-technology industries	Electrical machinery and apparatus Motor vehicles, trailers and semi-trailers
	Chemicals excluding pharmaceuticals
	Railroad equipment and transport equipment
	Machinery and equipment, n.e.c. (not elsewhere classified)
Medium-low-technology industries	Building and repairing of ships and boats
	Coke, refined petroleum products, and nuclear fuel
	Rubber and plastics products
	Other non-metallic mineral products
	Basic metals and fabricated metal products
Low-technology industries	Manufacturing n. e. c. and recycling
	Wood, pulp, paper, paper products, printing, and publishing
	Food products, beverages, and tobacco
	Textiles, textile products, leather, and footwear

Compare below the list of high-technology industries according to the classification of the United Nations Industrial Development Organization (UNIDO):

- Chemicals and chemical products;
- Office, accounting, and computing machinery;
- Electronics, radio, television and communication equipment and apparatus;
- Medical, precision, and optical instruments;
- Motor vehicles, trailers and semi-trailers, and other transport equipment;
- Machinery and equipment n.e.c.

As can be seen from the methodologies, there are no principal differences. The UN's methodology adopts a more aggregate approach without isolating such high-technology industries as the defense industry, aircraft and spacecraft, pharmaceuticals, and railroad equipment and transport.

The Russian approach to the classification of industries by the level of technology is based on the data of the UNIDO classification. A great number of manufacturers try to adopt innovations in their processes and, as a rule, the boundaries in classifications between the areas become very uncertain, as the process of identification of production with a specific manufacturing segment is challenging.

An analysis of the conceptual framework of the global market of high-technology products leads to an observation that even with the classifications of the OECD and the UNIDO, there is no formulated and well-aligned industry breakdown in the market of high-technology products. Each country proposes its concept of market segmentation, even if based on the above methodologies. The rules for charting the market by the industries are also inconsistent and different, as the threshold level of R&D cost content is different in different methodologies and the actual share can be hard to determine given that products of some industries are often used to manufacture products of other industries.

The Russian Government's stance regarding the support of high-technology projects is underscored in the Resolution of the Government of the Russian Federation of April 15, 2014, "Development of Science and Technology for 2013-2020" [9].

This resolution primarily prioritises the following areas of development of science and technology:

- Information and communication technology and electronics;
- Novel materials and chemical technology;
- Space and aviation technology;
- Emerging transport technology;

- Production technology;
- Advanced weaponry, military, and special equipment;
- Living system technology;
- Energy saving technology;
- Environmental and national natural management.

Based on the available lists, a conclusive list may be compiled as follows: aircraft and rocket building operations; computer equipment; motor vehicles; weaponry and military equipment; nanoelectronics; computers and office equipment; telecommunications and radio; medicine and pharmaceuticals; nuclear and nanotechnology; biotechnology.

3. Results

Risk is the effect of uncertainty on an expected result [10]. The underlying hypothesis of risk classification for high-technology production is that of risk factors, i. e., those circumstances, subjects, or processes that may limit business development and create the potential for missing the expected results. Risk factors can be considered as the preconditions for risk event materialisation.

The following risks may be included in the group of high-technology production.

- Deficit or difficulties in attracting funds;
- Skill shortage and difficulties of motivation;
- Product distribution;
- Organisational aspects of creating and operating a research-intense business;
- Production cycle specifics;
- Inadequacy of regulations.

Indeed, high-technology production businesses are particularly vulnerable among all types of businesses, as they deal with high costs and prolonged R&D operations, use expensive equipment and have to arrange for costly intellectual property protection. They have to cope with difficulties in market forecasting, strong reliance on co-producers and suppliers and extended production cycles. The division of risks by the areas of their emergence is one of the most practicable available classifications.

One of the most applicable classifications is dividing risks by the area of emergence. Note that this classification initially developed for traditional businesses can be adapted for the high-technology sector (Table 2).

Table 2- Classification of Risks of High-technology Production Businesses

Groups of risks	**Risks**
Organisational risks	irrational choice of organisation structure
	managers' and employees' mistakes
	issues in the internal control system
	lack or inferior quality of regulations governing the transition of managerial input, delineation of powers and responsibilities
	inferior quality of data collection, exchange, and registration
	inferior quality document flow
Legal risks	inconsistencies or possibilities of change in the applicable legislation
	state of contract relations of the business
	document flow quality from the legal perspective
Process and technology risks	condition and use of: means of labour (equipment, intangible assets, etc.); supplies (commodities, materials, finished products, costs in process, deferred expense); talent (human resources profile in terms of qualification, turnover, labour compliance, embezzlement, negligence, motivation, etc.); capital (equity, liabilities, working capital); entrepreneurial talent; information; specifics of the technological cycle
Financial risks	operations, i.e. current core business operations
	financial operations associated with attracting and investing financial resources for the short term and servicing short-term financial liabilities
	investment operations associated with attracting and investing capital for the long term, pursuing investment and capital spending
Innovation risks	economic instability (financial losses due to product price fluctuations, faltering demand, etc.)
	innovation planning and design framework for innovation operations/product (incorrect (elevated or understated) target levels and project parameters can potentially lead to financial deficits when credibility limits are exhausted, resulting in underfinancing in operations driven by cash flows from a specific innovation project, and in credit risks for the borrower and creditor)
	competitive factor (competitive advances in new product launches, loss of competitive positions, etc.)
	uncertainty in pulling out the whole cycle of R&D, from the initial product idea to the marketable finished product and to consolidating demand

Risk management as part of quality management systems in high-technology production businesses should be guided by the research and practical approach to decision-making implemented in well-documented, transparent, and reproducible methods of process at all stages integrating available knowledge of risk probability, severity, and detectability. It should become a systematic process for identifying the situation, planning, assessment, monitoring, control and analysis across the stages of the objects' life cycles [11].

In approaching risk management at high-technology production businesses, classifications of risks should serve as the basis for developing an algorithm for running analytical and regulatory procedures and identifying areas requiring additional focus.

Standard GOST R ISO 9001-2015 covers all major processes in an organisation, starting from leadership and management commitment and down to every stage of the production cycle. Thus, consider the risks of high-technology production in line with GOST R ISO 9001-2015.

The following groups of risks of high-technology production can be identified based on the requirements of GOST R ISO 9001-2015:

- Risks of unavailability or inadequate resource supply to meet internal and external resource needs for the design and development of products and services;
- Risks associated with insufficient knowledge input for maintaining the processes of high-technology production;
- Risks associated with low efficiency of measures to develop and implement design management tools.

Table 3 outlines the groups of risks and their description under each group; the risks are harmonised with the specified items of GOST R ISO 9001-2015 in the analysis above.

Table 3- Classification of Risks of High-technology Production based on GOST R ISO 9001-2015

Items GOST R ISO 9001	**Risk groups**	**Risk description**
4.4 6.1 7.1 7.2 8.3	Risks of unavailability or inadequate resource supply to meet internal and external resource needs for the design and development of products and services	Risk of shortage or unavailability of high-skilled top and medium level talent
		Risks of the impossibility of project implementation caused by the lack of equipment or limited available technical capacities
		Risks of regulatory deficiency and blind spots regarding high-technology production (lack of state programmes, presidential decrees, etc.)
		Risks of additional funding requirements in the project
4.4 6.1 8.3 8.5	Risks associated with insufficient knowledge input for maintaining the processes of high-technology production	Risks of inadequate project analysis and structuring by duration, scope, staff responsibilities, etc.
		Risk of information deficiency on previous similar operations of high-technology product design and development and potential consequences of failures in product characteristics
		Risk of flawed information security, untimely patent filing and failures with commercial secrecy

4. Discussion

Inadequate qualification level represents one of the most important problems in an organisation, specifically in high-technology projects, as it raises the risk of irreversible errors caused

by incompetence in operational nuances. To mitigate risks caused by a shortage or unavailability of high-skilled top and medium-level talent, consider the following prevention measures: talent training; engaging talent in a different process; engaging external talent to replace underperforming staff.

New technology implementation is directly tied to equipment. To mitigate the risks of the impossibility of project implementation caused by the lack of equipment or limited available technical capacities, consider the following prevention measures: modernisation of available equipment, purchases of new equipment.

The process of documenting information for high-technology production should refer to applicable international and domestic regulatory papers to mitigate risks caused by insufficient regulatory background preparation of high-technology production.

Risks of additional funding requirements in a project may result from different causes, such as multiplicity of financial sources; increase in the initial project cost, incorrect assessments of working capital requirements for the project, etc. However, such risks are usually associated with insufficient knowledge of high-technology operations. To mitigate them, special attention should be directed to the analysis of scientific and technical information (articles, monographs, scientific reports) in the same or related fields of international and local practice and participation in roundtables with prominent scientists and practitioners in the respective field and managerial talent with the purpose to develop an algorithm to pursue the set targets.

Information security plays a crucial role in high-technology production, given that competitors may take advantage of the insecure access to information and get ahead in implementing the new technology. To prevent it, consider complex measures, such as: maintaining commercial secrecy; introduction of information protection systems and measures; filing for patent protection for the organisation's research results, determining and maintaining effective operation of the organisation's information technology infrastructure.

5. Conclusion

High-technology production businesses are vulnerable to many risks as they have to cope with high costs, prolonged R&D operations, extended production cycles, and shortages of required high-skilled talent and with advanced and expensive equipment requirements.

Classifications of risks of high-technology production may rely on standard classifications expanded with input on sector-specific risks.

Risk-management processes in high-technology production should rely on the regulatory technical framework of the risk-based approach. This requirement becomes particularly relevant after the release of the latest version of standard GOST R ISO 9001-2015. Accordingly, risk classifications and applicable methodology development efforts should take into account the requirements of this standard.

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