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QUALITY RISK MANAGEMENT 5.0 OF INNOVATIVE PRODUCTS AS THE CORE OF THE INDUSTRIAL AND MANUFACTURING ENGINEERING SYSTEM IN HIGH-TECH PRODUCTION

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Abstract: *The research aims to develop a marketing-based approach to Quality Risk Management 5.0 for innovative products in high-tech manufacturing in developing countries. To this end, the authors conducted an econometric study of international experience in Quality Risk Management 5.0 in 2025 using regression and correlation analysis, focusing on developing countries with different income levels and belonging to different world regions. The new approach is grounded in a marketing model of Quality Risk Management 5.0 for innovative products in high-tech manufacturing in developing countries that has been developed by the authors. The approach includes a set of effective marketing methods of Quality Risk Management 5.0 tailored to developing countries from different world regions and belonging to different income categories (illustrated by lower-middle- and upper-middle-income countries). The novelty of the proposed approach lies in the integration of Quality Risk Management 5.0 for innovative products into the marketing mix (the 7P model) of high-tech manufacturing. The uniqueness of the approach also stems from the differentiation of marketing-based Quality Risk Management 5.0 methods in developing countries, depending on their income level.*

Keywords: *risk management, Quality 5.0, innovative products, cyber-social system, industrial and manufacturing engineering, high-tech manufacturing, developing countries.*

1. Introduction

Under the conditions of the Fifth Industrial Revolution, a new interpretation of the quality of industrial products has become established, one based on their high-tech nature. In recent scholarly literature (Thanoon, 2024; Woźniak et al., 2024), this understanding is denoted by the term "Quality 5.0." High-tech quality is interpreted in a broad sense, not limited to the technical complexity and innovativeness of the product itself, but also encompassing the alignment of business processes with a specific technological paradigm, the absence of defects, and the digital competitiveness of Industry 5.0 products.

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Only when innovative products of high-tech manufacturing achieve a high level of Quality 5.0 can they ensure the viability of entrepreneurial and investment activities in terms of commercial efficiency, as well as deliver benefits to the national socio-economic system by satisfying domestic demand for industrial products, facilitating the realization of export potential, and strengthening technological sovereignty. For this reason, Quality Risk Management 5.0 of innovative products deserves considerable attention from high-tech industrial enterprises.

Developed countries are characterized by the advanced development of socio-economic institutions that support technological progress, as well as by well-established digital infrastructure. As a result, they have created favorable conditions for market self-regulation in the rapidly growing Industry 5.0, which makes these countries leaders of the Fifth Industrial Revolution. Developing countries are distinguished by the traditional nature of their institutions, which slows technological progress, and by deficits in digital infrastructure. This makes the socio-economic environment in developing countries less conducive to the market processes of Industry 5.0.

To stimulate the innovative development of national socio-economic systems at the pace of the Fifth Industrial Revolution, governments in developing countries implement special measures. Active state intervention in the market processes of Industry 5.0 indicates that a regulatory approach to Quality Risk Management 5.0 of innovative products in national high-tech manufacturing is being applied in developing countries. At the initial stage of digital modernization, this regulatory approach was useful in that it enabled governments to rapidly create the institutional environment and infrastructural foundations necessary for integrating developing countries into the Fifth Industrial Revolution.

The problem is that at the current stage of digital modernization of the socio-economic systems of developing countries, which are already active participants in the Fifth Industrial Revolution, the regulatory approach to Quality Risk Management 5.0 of innovative products in national high-tech manufacturing is showing diminishing effectiveness. As developing countries continue to adhere to the regulatory approach, those that initially achieved a digital breakthrough have now slowed the pace of their digital development.

For this reason, developing countries are increasingly drifting away from their core goal of technological modernization, namely, achieving a level of digital development comparable to that of developed countries. Their lag behind the leaders of the Fifth Industrial Revolution is widening; their status as peripheral participants in this revolution is becoming entrenched. This deepens the global digital divide and, as a result, leads to a lower concentration of global markets for high-tech industrial products of Industry 5.0, slows economic growth, reduces income levels and quality of life in developing countries, and intensifies threats to their economic security.

In view of the above, the scientific search for a new approach to Quality Risk Management 5.0 of innovative products in high-tech manufacturing has become increasingly relevant: an approach that would serve as an alternative to the regulatory model, enhance the effectiveness of this managerial practice, and help narrow the global digital divide. On this basis, the objective of this research is defined as the development of a marketing-based approach to Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries.

In the empirical part of this research, the structure of the presentation of research materials is determined by the stated objectives. The first objective is to develop a methodological framework for marketing-based Quality Risk Management 5.0 of

innovative products in high-tech manufacturing in developing countries. The second objective is to identify the prospects for improving the Quality 5.0 of innovative products in high-tech manufacturing in developing countries through a transition to a marketing-based approach to managing this quality.

2. Literature Review

2.1. The Regulatory Approach to Quality Risk Management 5.0 of Innovative Products in High-tech Manufacturing

The research object is the Quality 5.0 of innovative products, which is subject to management within the cyber-social system of industrial and manufacturing engineering in high-tech production belonging to Industry 5.0. From a theoretical perspective, the research is grounded in the scientific concept of quality risk management for innovative products, according to which:

- Quality 5.0 of innovative products in high-tech manufacturing is defined as the set of characteristics of Industry 5.0 production systems and their products that influence their market position, assessed in terms of the share of these production systems in the overall industrial structure (Stefanovic et al., 2024);
- The Quality 5.0 risk of innovative products in high-tech manufacturing is interpreted as a deterioration in the characteristics of these production systems, leading to a worsening of their market position and accompanied by a reduction in their share in the overall industrial structure (Margaryan & Margaryan, 2022);
- Quality Risk Management 5.0 of innovative products in high-tech manufacturing is defined as a managerial practice of these production systems aimed at counteracting the risk of declining product quality (Manukyan & Parsyan, 2024).

Currently, developing countries apply a regulatory approach to Quality Risk Management 5.0 of innovative products in high-tech manufacturing. The implementing subject of this approach is public authorities responsible for economic governance, while the objects of management are high-tech enterprises that are state-owned and organized as state corporations. The regulatory approach provides for the use of the following three main methods of Quality Risk Management 5.0 of innovative products in high-tech manufacturing:

- Quality 5.0 certification, along with the standardization and regulation of high-tech manufacturing activities, which, on the one hand, ensure guarantees of Quality 5.0, its clarity, transparency, and predictability, and simplify quality control, but, on the other hand, constrain innovative activity and reduce the flexibility of high-tech enterprises (Paixão et al., 2026);
- Subsidized support for innovation aimed at improving Quality 5.0, which, on the one hand, provides financial assistance to high-tech enterprises during economic crises and reduces the cyclicality of national Industry 5.0, but, on the other hand, places a heavy burden on the national public budget and limits the financial resources available for the development of high-tech enterprises (Bogoviz et al., 2017);
- Protectionism in Industry 5.0, which, on the one hand, prevents price dumping by transnational corporations and encourages the development of national high-tech manufacturing, but, on the other hand, restricts competition among high-tech enterprises and weakens their incentives for innovative development, thereby slowing its pace (Djordjevic et al., 2025).

2.2. Marketing Aspects of Quality 5.0 in Innovative Products of High-tech Manufacturing

Under a marketing-based approach to Quality Risk Management 5.0 of innovative products in high-tech manufacturing, the subjects of management are the enterprises themselves, acting as market agents of Industry 5.0. They operate in a highly competitive environment and are motivated to demonstrate a high level of marketing activity. In this context, Quality Risk Management 5.0 of innovative products is embedded in the marketing mix of high-tech manufacturing, whose elements in the 7P model are as follows:

- P_1: "Price" – the costs affecting product prices that are associated with improving Quality 5.0, the most important of which are investments in telecommunication services (Elliott et al., 2025);
- P_2: "People" – IT specialists involved in high-tech manufacturing within Industry 5.0 (Babakhanova et al., 2024);
- P_3: "Place" – the intensity of industrial product distribution of Industry 5.0 in the digital environment (Litvinova et al., 2019);
- P_4: "Process" – the degree of smart automation of high-tech industrial production in Industry 5.0, achieved through the implementation of patented ICT innovations (Pyataeva, 2025);
- P_5: "Physical Evidence" – the cybersecurity of the digital environment in which the production and distribution processes of high-tech Industry 5.0 enterprises take place (Gunjal et al., 2024);
- P_6: "Product" – the uniqueness, progressiveness, and innovativeness of the industrial design of products from high-tech Industry 5.0 enterprises, created through the implementation of relevant patents (Smetanin et al., 2025);
- P_7: "Promotion" – the degree to which Quality 5.0 innovations are integrated into the market promotion of innovative products from high-tech manufacturing enterprises (Bencic, 2022; Bogoviz et al., 2020).

A review of the available literature on the topic demonstrates a high level of scholarly development, while also revealing a gap related to the insufficient clarity regarding the contribution of each element of the marketing mix to reducing Quality 5.0 risks in innovative products of high-tech manufacturing. Accordingly, this article poses the research question of how marketing mix methods influence the Quality 5.0 of innovative products in high-tech manufacturing and which of these methods are most effective for managing the risks associated with this quality.

Certain manifestations of empirical experience in the use of marketing within the practice of Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries are discussed in the published studies by Benčič et al. (2020) and Vechkinzova et al. (2019), which highlight substantial differences in the effectiveness of marketing methods across world regions. On this basis, the article advances a hypothesis (H), stating that the usefulness of marketing methods for Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries varies across world regions.

3. Materials and Methods

3.1. Factual Basis of the Research

To clarify the marketing aspects of Quality 5.0 in innovative products of high-tech manufacturing, this article examines international experience in Quality Risk Management 5.0, drawing on UNDP and MBRF (2024) statistics for 2025. The sample includes four countries from each of the six

world regions that comprise developing economies. Within each region, countries with different income levels were included in the sample wherever possible.

In regions such as Europe and Central Asia, East Asia and Pacific, Latin America and Caribbean, and Sub-Saharan Africa, the sample includes two upper-middle-income and two lower-middle-income countries. In the Middle East and North Africa, three lower-middle-income countries and one upper-middle-income country were selected. In South Asia, due to the absence of countries with other income levels for which the required statistics are available, only lower-middle-income countries were included. The empirical basis of the study is presented in Table 1.

Table 1. Quality Risk Management 5.0 of Innovative Products in High-tech Manufacturing Across World Regions in 2025

Region of the world	Country income level	Country	Investment in telecommunication services, % GDP	ICT employment, %	Trade in digitally deliverable services, % total trade	ICT PCT patent applications, per 1000 billion GDP	Secure Internet services per 1 million population, pcs.	Industrial design applications, per 1000 billion GDP	Firms with products and services new to the market, %	Medium and high-tech activities value added, % of total manufacturing value
			P_1	P_2	P_3	P_4	P_5	P_6	P_7	IP5.0Q
Europe and Central Asia	Upper middle	Armenia	15.4	31.5	18.2	36.8	50.4	60.9	74.8	6.7
	Lower middle	Kyrgyzstan	27.4	10.8	16.3	50.6	47.2	37.3	70.5	2.2
	Upper middle	Serbia	51.4	52.9	54.6	47.4	72.5	47.5	47.2	28.8
	Lower middle	Uzbekistan	13.3	0.0	8.6	20.5	48.1	50.9	67.2	18.8
East Asia and the Pacific	Lower middle	Philippines	27.6	9.0	48.9	20.7	36.4	52.6	78.4	31.1
	Lower middle	Viet Nam	12.1	6.6	17.3	20.8	63.5	61.6	67.2	41.6
	Upper middle	China	27.1	0.0	43.5	86.2	53.8	100.0	0.0	44.6
	Upper middle	Indonesia	12.2	3.5	58.6	0.4	59.4	55.7	75.4	32.0
Latin America and the Caribbean	Upper middle	Brazil	20.1	21.6	61.8	36.3	63.4	60.3	0.0	33.7
	Upper middle	Mexico	20.8	9.3	39.0	26.7	45.	20.4	43.3	45.6
	Lower middle	Bolivia	41.4	6.6	19.7	0.0	41.4	38.5	71.4	12.7
	Lower middle	Honduras	36.2	4.6	16.7	0.0	35.3	0.0	74.2	7.5

Middle East and North Africa	Lower middle	Pakistan	13.4	5.5	37.4	0.0	32.8	45.3	0.0	24.5
	Lower middle	Tunisia	16.0	16.9	12.9	33.5	45.0	71.7	75.4	29.6
	Lower middle	Jordan	29.2	16.0	2.3	37.7	37.5	55.5	59.9	21.4
	Upper middle	Iran	34.3	11.0	14.7	43.6	61.2	79.0	0.0	39.1
South Asia	Lower middle	Bangladesh	7.0	2.7	20.3	1.7	38.2	55.2	0.0	8.2
	Lower middle	Bhutan	12.5	7.8	8.5	0.0	51.2	39.6	61.7	0.0
	Lower middle	India	13.0	18.9	73.0	44.9	48.2	64.7	69.1	44.7
	Lower middle	Sri Lanka	12.2	10.7	26.5	30.9	46.5	44.7	0.0	9.5
Sub-Saharan Africa	Lower middle	Angola	9.4	3.7	26.8	18.6	22.4	32.9	0.0	3.6
	Lower middle	Benin	20.4	3.9	12.5	0.0	21.6	24.8	53.9	0.0
	Upper middle	Botswana	24.4	7.2	60.0	40.8	42.8	39.2	58.2	30.8
	Upper middle	South Africa	31.7	0.0	54.7	45.6	76.0	53.1	60.9	26.2

Source: Developed by the authors based on the materials from UNDP and MBRF (2024).

As reflected in Table 1, the intensity of applying marketing methods of Quality Risk Management 5.0 is measured using the following indicators, structured according to the elements of the marketing mix in the 7P model:

- The monetary volume of private investment in telecommunication services (P_1);
- The share of ICT employment (P_2);
- The share of digital sales in the structure of trade (P_3);
- The monetary volume of ICT patents (P_4);
- The prevalence of cyber-secure Internet services (P_5);
- The monetary volume of industrial design assets (P_6);
- The share of enterprises producing innovative products that are new to the market, i.e., fundamentally new (P_7).

The indicator of Quality 5.0 in innovative products of high-tech manufacturing is the share of these manufacturing activities in the overall industrial structure (IP5.0Q).

3.2. Methods for Addressing the Research Objectives

The first objective of this research is to develop a methodological framework for marketing-based Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries. This objective is addressed through regression analysis, which is used to determine the dependence of the Quality 5.0 of innovative products in high-tech manufacturing (IP5.0Q) on the factors reflecting the application of marketing management methods (P_1-P_7) across the entire sample comprising 24 observations. Positive regression coefficients indicate a positive impact of the respective factors.

Correlation analysis is also employed to assess the relationship between the application of marketing management methods (P_1-P_7) and the Quality 5.0 of innovative products in high-tech

manufacturing (IP5.0Q) separately for each of the six analyzed world regions and for each income-level group of countries. This makes it possible to exclude methods that are ineffective for countries in a given region or income group, as indicated by negative correlation coefficients.

The second objective of the research is to identify the prospects for improving the Quality 5.0 of innovative products in high-tech manufacturing in developing countries through a transition to a marketing-based approach to Quality Risk Management 5.0. This objective is addressed by identifying the maximum values of the indicators reflecting the intensity of applying marketing management methods (P_1-P_7) across the entire sample from Table 1 and substituting them into the previously constructed regression equation, while excluding, for each region, the methods that are ineffective there, based on regional specificities. In this way, a forecast of Quality 5.0 growth through 2030 is constructed for all the world regions under study.

4. Results

4.1. Marketing-based Quality Risk Management 5.0 of Innovative Products in High-tech Manufacturing in Developing Countries

In addressing the first objective of this research, the authors conducted a regression analysis of the statistics presented in Table 1. The dependence of the Quality 5.0 of innovative products in high-tech manufacturing (IP5.0Q) on the factors reflecting the application of marketing management methods (P_1-P_7) across the examined sample of 24 countries in 2025 is described by the following regression model (1):

$$IP5.0Q=-13.039+0.145P_1-0.187P_2+0.344P_3+0.042P_4+0.122P_5+0.308P_6+0.033P_8 \quad (1)$$

Based on model (1), in developing countries, a 1% of GDP increase in the monetary volume of private investment in telecommunication services contributes to a 0.145% rise in the share of high-tech manufacturing in the overall industrial structure. An increase of 1% in the share of digital sales within the structure of trade leads to a 0.344% growth in the share of high-tech manufacturing in the overall industrial structure.

An increase in the monetary volume of ICT patents by 1 per 1,000 billion GDP ensures a 0.042% rise in the share of high-tech manufacturing in the overall industrial structure. Expanding the prevalence of cyber-secure Internet services by one unit per one billion people is accompanied by a 0.122% increase in the share of high-tech manufacturing in the overall industrial structure. An increase in the monetary volume of industrial design assets by 1 per 1,000 billion GDP results in a 0.308% growth in the share of high-tech manufacturing in the overall industrial structure.

An increase of 1% in the share of enterprises producing innovative products that are new to the market leads to a 0.033% rise in the share of high-tech manufacturing in the overall industrial structure. At the same time, the involvement of IT specialists in high-tech manufacturing does not contribute to improving the Quality 5.0 of innovative products in these industries. On the contrary, an increase in the share of ICT employment, instead of the expected improvement, reduces the share of high-tech manufacturing in the overall industrial structure by 0.187%. In this regard, P_2 (“People”) in the 7P model of Quality Risk Management 5.0 is not an effective marketing method in developing countries.

Second, a correlation analysis of the data from Table 1 was conducted, as a result of which the strength of the relationship between the application of marketing management methods (P_1-P_7) and the Quality 5.0 of

innovative products in high-tech manufacturing (IP5.0Q) was quantitatively measured separately for each of the six analyzed world regions and for each income group of countries (Table 2).

Table 2. Correlation between marketing mix quality indicators 5.0 and IP5.0Q

Economic systems		P_1	P_2	P_3	P_4	P_5	P_6	P_7
By region	Europe and Central Asia	0.59	0.49	0.69	-0,17*	0.81	0.11	-0.88*
	East Asia and the Pacific	0.07	-0.58*	-0.63*	0,77	0.49	0.82	-0.80*
	Latin America and the Caribbean	-0.91*	0.55	0.74	0,88	0.58	0.35	-0.68*
	Middle East and North Africa	0.45	-0.06*	-0.02*	0,47	0.95	0.85	-0.39*
	South Asia	0.34	0.85	0.997	0,84	0.11	0.88	0.46
	Sub-Saharan Africa	0.72	0.08	0.99	0,94	0.77	0.79	0.57
By income level	Lower middle	-0.13*	0.48	0.54	0,39	0.46	0.70	0.30
	Upper middle	0.13	-0.45*	0.17	0,21	-0.13*	0.09	-0.63*

Note: * correlation coefficients with negative values.
Source: Developed by the authors.

Based on the correlation relationships identified and presented in Table 2, in addition to the previously excluded method P_2 ("People"), other methods that proved ineffective in countries of specific regions and income levels were also excluded, as indicated by negative correlation coefficients. In developing countries from Europe and Central Asia, no Quality 5.0 benefits were identified from the marketing methods P_4 ("Process") and P_7 ("Promotion"), while in East Asia and the Pacific, the ineffective methods were P_3 ("Place") and P_7 ("Promotion").

In developing countries from Latin America and the Caribbean, the marketing methods P_1 ("Price") and P_7 ("Promotion") were found to be ineffective with respect to Quality 5.0, whereas in the Middle East and North Africa, method P_7 ("Promotion") proved ineffective. Unlike the other regions, South Asia and Sub-Saharan Africa emerged as regions where developing countries achieve substantial returns from marketing methods in terms of Quality 5.0. In developing countries with a lower-middle-income level, no positive effect on Quality 5.0 was identified from the marketing management method P_1 ("Price"). In contrast, in developing countries with an upper-middle-income level, methods P_5 ("Physical Evidence") and P_7 ("Promotion") were ineffective.

Thus, a methodological framework for marketing-based Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries has been formed. It includes an econometric model that mathematically characterizes the overall contribution of each marketing risk management method to the formation of Quality 5.0 in innovative products of high-tech manufacturing, as well as tailored sets of Quality 5.0 management methods that are effective in each specific world region and in country groups with a given income level.

4.2. Prospects for Quality 5.0 Growth in Developing Countries Through a Transition to a Marketing-based Approach to its Risk Management

In addressing the second objective of this research, the maximum values of the indicators reflecting the intensity of applying marketing management methods (P_1, P_3–P_7) across the entire sample from Table 1 were identified. The highest value in the sample for the monetary volume of private investment in

telecommunication services was 51.40% of GDP. The maximum share of digital sales in the structure of trade reached 73.00%.

The maximum monetary volume of ICT patents amounted to 86.20 per 1000 billion GDP. The highest prevalence of cyber-secure Internet services (per one billion people) was 76.00 units. The maximum monetary volume of industrial design assets reached 100.00 per 1000 billion GDP. The maximum share of enterprises producing innovative products that are new to the market was 78.40%.

These maximum values were substituted into model (1) only for the marketing risk management methods that proved effective for Quality Risk Management 5.0 in developing countries in each world region, considering their identified specificities. As a result, a forecast of Quality 5.0 growth through 2030 was constructed for all the world regions under study and is presented in Table 3.

Table 3. Current (2025) and projected (2030) values of Quality 5.0 variables across world regions

Variable	Europe and Central Asia		East Asia and the Pacific		Latin America and the Caribbean		Middle East and North Africa		South Asia		Sub-Saharan Africa	
P_1	26.88	51.40	19.75	51.40	29.63 (const)		23.23	51.40	11.18 (const)		21.48	51.40
P_2	23.80 (const)		4.78 (const)		10.53 (const)		12.35 (const)		10.03 (const)		3.70 (const)	
P_3	24.43	73.00	42.08 (const)		34.30	73.00	16.83 (const)		32.08	73,00	38.50	73.00
P_4	38.83 (const)		32.03	86.20	15.75	86.20	28.70	86.20	19.38	86,20	26.25	86.20
P_5	54.55	76.00	53.28	76.00	46.28	76.00	44.13	76.00	46.03	76.00	40.70	76.00
P_6	49.15	100.00	67.48	100.00	29.80	100.00	62.88	100.00	51.05	100.00	37.50	100.00
P_7	64.93 (const)		55.25 (const)		47.23 (const)		33.83 (const)		32.70	78.40	43.25	78.40
IP5.0Q	14.13	39.20	37.33	65.16	24.88	87.44	28.65	53.14	15.60	41.94	15.15	47.57

Source: Developed by the authors.

According to Table 3, to fully unlock the potential for improving (relative to 2025) the Quality 5.0 of innovative products in high-tech manufacturing in developing countries from Europe and Central Asia, it is recommended to increase the monetary volume of private investment in telecommunication services by 91.22%, raise the share of digital sales in the structure of trade by 198.81%, expand the prevalence of cyber-secure Internet services by 39.32%, and increase the monetary volume of industrial design assets by 103.46%.

In developing countries from East Asia and the Pacific, it is proposed to increase the monetary volume of private investment in telecommunication services by 160.25%, expand the monetary volume of ICT patents by 169.12%, increase the prevalence of cyber-secure Internet services by 42.64%, and raise the monetary volume of industrial design assets by 48.19%.

In developing countries from Latin America and the Caribbean, it is advisable to increase the share of digital sales in the structure of trade by 112.83%, expand the monetary volume of ICT patents by 447.30%, increase the prevalence of cyber-secure Internet services by 64.22%, and raise the monetary volume of industrial design assets by 235.57%.

In developing countries from the Middle East and North Africa, an increase in the monetary volume of private investment in telecommunication services by 121.27% is required, along with an expansion of the monetary volume of ICT patents by 200.35%, an increase in the prevalence of cyber-secure Internet services by 72.22%, and a rise in the monetary volume of industrial design assets by 59.03%.

In developing countries from South Asia, it is necessary to raise the share of digital sales in the structure of trade by 127.56%, expand the

monetary volume of ICT patents by 344.79%, increase the prevalence of cyber-secure Internet services by 65.11%, raise the monetary volume of industrial design assets by 95.89%, and increase the share of enterprises producing innovative products that are new to the market by 139.76%.

In developing countries from Sub-Saharan Africa, the monetary volume of private investment in telecommunication services should be increased by 139.29%, the share of digital sales in the structure of trade raised by 89.61%, the monetary volume of ICT patents expanded by 228.38%, the prevalence of cyber-secure Internet services increased by 86.73%, the monetary volume of industrial design assets raised by 166.67%, and the share of enterprises producing innovative products that are new to the market increased by 81.27%.

The expected practical benefits of implementing the proposed measures to improve Quality Risk Management 5.0 in developing countries across different world regions through 2030, based on a tailored set of marketing methods selected for each region, are illustrated in Figure 1.

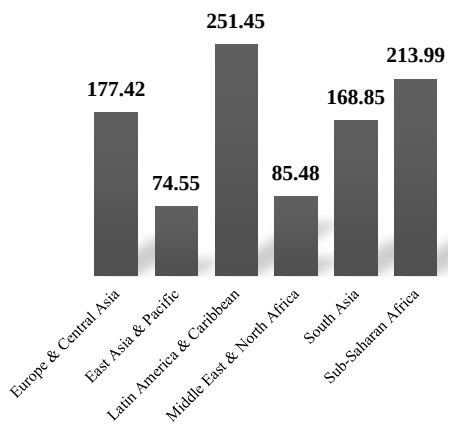

Figure 1. The potential for Quality 5.0 growth of innovative products across world regions through 2030, compared with 2025, %. *Source:* Developed by the auth ors.

As shown in Figure 1, the transition to a marketing-based approach to Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries is projected to lead, by 2030, to a substantial increase (relative to 2025) in the share of high-tech manufacturing in the overall industrial structure: by 177.42% (to 39.20%) in Europe and Central Asia, by 74.55% (to 65.16%) in East Asia and Pacific, and by 251.45% (to 87.44%) in Latin America and Caribbean.

The implementation of the author's recommendations for marketing-based risk management of Quality 5.0 in innovative products of high-tech manufacturing in developing countries from the Middle East and North Africa will ensure, by 2030, an increase (compared with 2025) in the share of high-tech manufacturing in the overall industrial structure by 85.48% (to 53.14%). The increase is projected at 168.85% (to 41.94%) in South Asia and 213.99% (to 47.57%) in Sub-Saharan Africa.

Thus, the author's forecast demonstrates that the transition to a marketing-based approach to Quality Risk Management 5.0 opens broad prospects for improving the Quality 5.0 of innovative products in high-tech manufacturing in developing countries by 2030.

5. Discussion

The results and conclusions drawn from them continue the line of research by Manukyan and Parsyan (2024), Margaryan and Margaryan (2022), Stefanovic et al. (2024), Thanoon (2024), and Woźniak et al. (2024) and further develop the scientific concept of quality risk management of innovative products by refining the possibilities and limitations of applying marketing methodology to Quality Risk Management 5.0 of innovative products within the cyber-social system of industrial and manufacturing engineering in high-tech manufacturing belonging to Industry 5.0 (Table 4).

Table 4. Opportunities and limitations of marketing methods for Quality Risk Management 5.0 in developing countries by region of the world

World regions	**The presence of clearly expressed benefits for Quality 5.0 from marketing complex methods**						
	P_1	P_2	P_3	P_4	P_5	P_6	P_7
Europe and Central Asia	+	-	+	-	+	+	-
East Asia and the Pacific	+	-	-	+	+	+	-
Latin America and the Caribbean	-	-	+	+	+	+	-
Middle East and North Africa	+	-	-	+	+	+	-
South Asia	-	-	+	+	+	+	+
Sub-Saharan Africa	+	-	+	+	+	+	+
Disclosure of methods in existing literature	Elliott et al. (2025)	Babakhanova et al. (2024)	Litvinova et al. (2019)	Pyataeva (2025)	Gunjal et al. (2024)	Smetanin et al. (2025)	Bencic (2022), Bogoviz et al. (2020)

Source: Developed by the authors.

The results summarized in Table 4 demonstrate that the research hypothesis (H) has been confirmed and, in line with Benčič et al. (2020) and Vechkinzova et al. (2019), show that the effectiveness of marketing methods for Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries varies across world regions.

Unlike Elliott et al. (2025) the price-related costs of improving Quality 5.0, mainly investments in telecommunication services (P_1: "Price"), prove to be an effective marketing instrument for Quality Risk Management 5.0 in developing countries only in regions such as Europe and Central Asia, East Asia and Pacific, Middle East and North Africa, and Sub-Saharan Africa, but not in Latin America and Caribbean or South Asia.

Unlike Babakhanova et al. (2024), IT specialists engaged in high-tech manufacturing within Industry 5.0 (P_2: "People") do not constitute an effective marketing method for Quality Risk Management 5.0 of innovative products in developing countries in any world region.

Unlike Litvinova et al. (2019), the intensity of distributing Industry 5.0 industrial products in the digital environment (P_3: "Place") yields a clearly positive effect on the growth of Quality 5.0 in innovative products of high-tech manufacturing in developing countries only in Europe and Central Asia, Latin America and Caribbean, South Asia, and Sub-Saharan Africa, but not in East Asia and Pacific or the Middle East and North Africa.

Unlike Pyataeva (2025), the degree of smart automation of high-tech industrial production in Industry 5.0, achieved through the implementation of patented ICT innovations (P_4: "Process"), is an effective marketing instrument for Quality Risk Management 5.0 in developing countries only in East Asia and Pacific, Latin America and Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa, but not in Europe and Central Asia.

In support of Gunjal et al. (2024), the cybersecurity of the digital environment in which the production and distribution processes of high-tech Industry 5.0 enterprises take place (P_5: "Physical Evidence") provides a clearly positive contribution to the growth of Quality 5.0 in innovative products of high-tech manufacturing in developing countries across all world regions.

Confirming Smetanin et al. (2025), the uniqueness, progressiveness, and innovativeness of the industrial design of

products from high-tech Industry 5.0 enterprises, created through the implementation of relevant patents (P_6: "Product"), represent an effective marketing instrument for Quality Risk Management 5.0 in developing countries in all world regions.

Unlice Bencic (2022) and Bogoviz et al. (2020), the degree of integration of Quality 5.0 innovations into the market promotion of innovative products from high-tech manufacturing enterprises (P_7: "Promotion") yields a clearly positive effect on the growth of Quality 5.0 in innovative products of high-tech manufacturing in developing countries only in South Asia and Sub-Saharan Africa, but not in Europe and Central Asia, East Asia and Pacific, Latin America and Caribbean, or the Middle East and North Africa.

6. Conclusion

Based on the results of the conducted study, a marketing-based approach to Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries has been developed. Its distinctive features compared with the existing (regulatory) approach are as follows. The first feature is that, in the proposed approach, Quality Risk Management 5.0 of innovative products is embedded in the marketing mix (the 7P model) of high-tech manufacturing.

The second feature is that the new approach provides for the differentiation of marketing methods of Quality Risk Management 5.0 for innovative products in high-tech manufacturing in developing countries, depending on their income level, specifically distinguishing between lower-middle-income and upper-middle-income countries. The third feature is that the proposed approach considers the specific characteristics of each world region and allows the marketing methodology of Quality Risk Management 5.0 to be flexibly adapted to the unique market environment of the innovative economy of each individual region.

The developed approach includes, first, a marketing model of Quality Risk Management 5.0 for innovative products in high-tech manufacturing in developing countries. Second, it comprises a set of effective marketing methods of Quality Risk Management 5.0 for developing countries belonging to different world regions and different income categories (illustrated by lower-middle- and upper-middle-income countries). Third, it offers scientific and practical recommendations for improving marketing-based Quality Risk Management 5.0 of innovative products in high-tech manufacturing to fully unlock the potential for improving this quality in developing countries by 2030.

The final authorial conclusion is that the usefulness of marketing methods for Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries varies significantly across world regions, as well as across country groups with different income levels. This necessitates consideration of the financial and geographical characteristics of each group of developing countries when applying these methods.

The theoretical contribution of the new approach to the development of the methodology of Quality Risk Management 5.0 for innovative products in high-tech manufacturing lies in the fact that it specifies and quantitatively measures the contribution of all elements of the marketing mix (the 7P model) to this quality and identifies the conditions under which this contribution can be achieved in developing countries, depending on their income level and geographical location (membership in a particular world region).

The practical value of the methodological developments and applied recommendations lies in the fact that their implementation will make it possible to optimize the managerial framework of the cyber-social system of industrial and manufacturing engineering in high-tech manufacturing, enhance the

effectiveness of Quality Risk Management 5.0 of innovative products as the core of this system, and ensure confident and accelerated growth of Quality 5.0 in developing countries in support of narrowing the global digital divide.

According to the author's forecast, adopting a marketing-based approach to Quality Risk Management 5.0 of innovative products in high-tech manufacturing in developing countries by 2030 will lead to an increase in the share of high-tech manufacturing in the overall industrial structure by 177.42% in Europe and Central Asia, by 74.55% in East Asia and Pacific, by 251.45% in Latin America and Caribbean, by 85.48% in the Middle East and North Africa, by 168.85% in South Asia, and by 213.99% in Sub-Saharan Africa.

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