

AUTOMATION BASED ON DATASETS AND AI OF CORPORATE ACCOUNTING AND SUSTAINABILITY REPORTING IN QUALITY MANAGEMENT IN INDUSTRY 4.0

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ABSTRACT

The article aims to improve the approach to product quality management in industry 4.0 by substantiating the feasibility and developing recommendations for automation based on datasets and AI of corporate accounting and sustainability reporting. Based on the international empirical experience for 2022 and official statistics, the article has revealed the importance of corporate accounting and sustainability reporting for product quality in industry 4.0 through regression analysis. The significant role of AI-driven automation in the development of corporate accounting and sustainability reporting practices has also been substantiated. The theoretical significance lies in the fact that the article has clarified the structure of the product quality of industry 4.0. In addition to Quality 4.0, a new quality component has been highlighted: product sustainability, the achievement of which depends not only on the implementation of the SDGs by the business, but also on the effectiveness of its management information systems. The central role of the effectiveness of management information systems in quality management of products in industry 4.0 to achieve their sustainability has also been substantiated. The practical significance of the article is related to the fact that the article has revealed the prospects (Pareto-optima) and proposed the authors' recommendations for improving quality in industry 4.0 in countries with emerging practices of corporate accounting and sustainability reporting – Estonia, Israel, Russia, Saudi Arabia and Turkey – through the automation of this practice based on AI. The obtained and mathematically described models can be used to reveal prospects and develop recommendations in other countries of the world. The managerial significance is expressed in the fact that the developed authors' mechanism will improve the practice of quality management in industry 4.0 through automation based on datasets and AI of corporate accounting and sustainability reporting. The advantage of the improved mechanism is the higher effectiveness of management information systems of enterprises in industry 4.0.



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1. INTRODUCTION

Sustainable development is a unique phenomenon of the XXI century, which has reached global coverage and made possible due to tectonic shifts in the environment (climate change, environmental pollution, environmental disasters of industrial origin, deterioration of the epidemiological situation), the state (the formation of international and national institutions for sustainable development) and society (the formation of a civil society supporting the SDGs and popularization responsible consumption).

The only economic entity that does not fully share the interests of sustainable development remains entrepreneurship, whose involvement is constrained and limited by the lack of a mechanism for commercialization of business support for the SDGs. This is due to the fact that business practices in support of the SDGs require resources corresponding to their content and scale, that is, they increase the cost of business products.

This makes it possible to formulate a scientific argument in favor of commercialization, due to the fact that with a shortage of the resource base, business structures are unable to carry out measures to implement the SDGs in their business practices, despite their active support and request for these measures from senior management and employees. In the conditions of economic crises, business structures experience an acute shortage of resources, and non-profit projects in the field of sustainable development can lead to losses, due to which the business will have to be liquidated.

Commercialization opens up the opportunity to consider financing the SDGs as investments that will not only pay off, but also bring additional income, as they will stimulate sales volume growth. If investments in the SDGs serve the interests of strengthening the market position of business, they will be carried out as a priority, for which the possibilities of attracting external resources, including borrowed funds, will be used.

Nevertheless, outstanding achievement have been made in the field of business participation in sustainable development projects in certain sectors of the economy. As an example is agriculture, in whose economic practice much attention is paid to the naturalness of food (Litvinova et al., 2016). Another good example is retail trade, in which the ideas of sustainable development are actively promoted, in particular, through the transition to more environmentally friendly packaging of goods. The energy sector has not been left out either – energy companies are actively implementing a “green” transition, developing and promoting “clean” energy on the market (Vechkinzova et al., 2022).

Corporate accounting and sustainability reporting play an important role in the process of commercialization of business support for the SDGs, largely determining the

success of this process. Thus, through corporate accounting and reporting in management information systems, communications with stakeholders and information assistance to initiatives implemented by businesses in support of the SDGs are carried out.

Special attention should be paid to the unique experience of industry 4.0 – high-tech markets, since, firstly, the elasticity of demand for quality is especially high in these markets and, secondly, the possibilities for optimizing corporate accounting and reporting are the widest due to the increased availability of advanced automation tools. However, the problem lies in the imperfection of the existing approach to product quality management in industry 4.0. In this approach, attention is focused on improving the technical properties of products of industry 4.0 with insufficient attention to additional opportunities to improve product quality through the implementation of the SDGs, corporate accounting and sustainability reporting.

This article aims to provide scientific and methodological support for solving this problem and seeks to improve the approach to product quality management in industry 4.0 by justifying the feasibility and developing recommendations for automation based on datasets and AI of corporate accounting and sustainability reporting. To achieve this purpose, firstly, the importance of corporate accounting and sustainability reporting for product quality in industry 4.0 is determined.

Secondly, the role of AI-based automation in the development of corporate accounting and sustainability reporting practices is revealed. Thirdly, the prospect of improving quality in industry 4.0 in countries with emerging practices of corporate accounting and sustainable development reporting through automation of this practice based on AI is disclosed. Fourthly, an improved quality management mechanism in industry 4.0 is proposed through automation based on datasets and AI of corporate sustainability accounting and reporting.

2. LITERATURE REVIEW

2.1. The existing mechanism of product quality management in industry 4.0: disadvantages from the perspective of sustainable development

The fundamental basis of this research is the theory of product quality management. According to this theory, the existing mechanism of product quality management in industry 4.0 involves such management practices as production management, innovation management, standardization and quality control. The result of this mechanism is Quality 4.0 (Canbay and Akman, 2023; Saihi et al., 2023). The disadvantages of the current approach from the standpoint of sustainable development are related to the fact that it excludes sustainable practices from the field of quality

management, that is, it does not provide commercialization of business support for the SDGs in industry 4.0, which hinders the development of such support.

Content analysis of the existing literature of Cammarano et al. (2022), Datta and Goyal (2022), Rendtorff (2023) indicates that the implementation of the SDGs, corporate accounting and sustainability reporting increase the competitiveness of responsible business products. In this article, it is proposed to interpret this phenomenon from the standpoint of quality, improved due to the sustainability of products. Despite the examples from different industries, the experience and specifics of the phenomenon under consideration in industry 4.0 have not been sufficiently developed in the available literature, which is a gap in it and raises the following research question.

RQ₁: What is the impact of corporate accounting and sustainability reporting on product quality in industry 4.0? In accordance with the existing literature, two main criteria are identified that allow quantifying the product quality in industry 4.0:

- Medium and high-tech manufacturing value added as an indicator of the volume of production of products in industry 4.0, the logic of which is that the higher the quality, the greater the demand and, accordingly, the greater the volume of production (Soniewicki, 2022; Tolmachev et al., 2023);
- High-technology exports as an indicator of the volume of exports of products in industry 4.0, the logic of which is that the higher the quality, the greater the international demand and, accordingly, the greater the volume of exports (Han and Zhou, 2022; Küçükkale and Adalı, 2021).

The works of Dias Lopes et al. (2023), Khan et al. (2023) give the opinion that corporate accounting and sustainability reporting do not affect the quality of products in industry 4.0 – neither the volume of its production nor the scale of its exports. The argumentation of these authors is based on the fact that the products of industry 4.0 have a limited range of substitute goods and therefore enjoy consistently high demand, determined mainly by its technical properties, that is, Quality 4.0

In contrast, Da Silva et al. (2023), Ed-Dafali et al. (2023) in their works argue that corporate social and environmental responsibility is important when stakeholders (not limited to consumers) make decisions on cooperation with enterprises of industry 4.0. Based on this, **the hypothesis H₁** is put forward in this article: corporate accounting and sustainability reporting determine the quality of products in industry 4.0, contributing to the growth of: 1) medium and high-tech manufacturing value added; 2) high-technology exports.

The economic meaning of this hypothesis is that sustainable products of industry 4.0 have a higher competitiveness compared to standard products of Quality 4.0. To verify the validity of the hypothesis put forward in this article, the econometric modeling of the dependence of medium and high-tech manufacturing value added and high-technology exports on the activity of corporate accounting and the publication of sustainable development reports is carried out.

2.2 Corporate accounting and sustainability reporting practices

The issues of corporate sustainability accounting and reporting have been studied in sufficient detail and covered in the available literature by Appannan et al. (2023), Nicolò et al. (2023), Sun (2023). The practices of this accounting and reporting are implemented in management information systems and ensure the commercialization of business support for the SDGs (Gotgelf, 2022; Ilina et al., 2019; Wang et al., 2023). In this regard, based on the works of Cardoso et al. (2022), Grgurevic et al. (2022), the sustainability of products as a new component of its quality, highlighted in this article, depends not only on the implementation of the SDGs by the business, but also on the effectiveness of its management information systems.

Without corporate accounting and reporting, these initiatives are in danger of going unremarked or undervalued. Detailed and systematic corporate accounting makes it possible to most accurately and reliably determine both the list of implemented initiatives and their benefits for sustainable development (Cerciello et al., 2023). And the publication of corporate reports on sustainable development makes it possible to correctly convey this information in the interpretation of the business entities themselves (without distorting the information by intermediaries, for example, rating agencies) to a wide range of stakeholders, that is, to ensure transparency of the initiatives under consideration (Silva et al., 2022).

Support of the SDGs together with corporate accounting and publication of corporate reports on sustainable development changes, namely - improves the quality of products of responsible business. In the “Decade of Action”, the competitiveness of responsible business products increases due to higher quality (with similar technical properties compared to competitors' products) and even at a higher price due to the price premium for supporting the SDGs (Surjanti et al., 2019).

In the absence, incompleteness or unreliability of corporate reporting, as well as in the case when sustainability reporting is published irregularly or is not transparent enough, stakeholders may show reduced loyalty to business due to insufficient awareness. In markets where mass support for the SDGs is not practiced, this can lead to a decrease in the

competitiveness of products of responsible businesses that really support the SDGs, but do not inform their stakeholders about it, due to higher prices compared to similar competitors' products of equivalent quality (Bazrkar et al., 2022).

In markets where, on the contrary, mass support for the SDGs is practiced, a responsible business with inefficient management information systems will also incur losses, since the quality of its products will be lower compared to the products of competitors who successfully inform stakeholders about their support for the SDGs. Responsible businesses are being pushed out of both types of markets due to the unrealized potential for improving the quality of their products (Kusmantini et al., 2021).

In the publications of Bogoviz (2020), wide opportunities for improving the effectiveness of management information systems with the help of advanced technologies such as artificial intelligence (AI) and datasets are noted. Nevertheless, the impact of product sustainability on its quality in Industry 4.0 has not been sufficiently studied in the available literature and remains uncertain. This is a gap in it and raises the following research question.

RQ₂: What is the contribution of AI-based automation to the development of corporate accounting and sustainability reporting practices? In the publications of Dumitru et al. (2023), Matthies (2020), it is suggested that corporate sustainability accounting and reporting are specific (not regulated and not controlled by the state) and therefore are not subject to automation. At the same time, Ergasheva et al. (2021), Lulaj et al. (2023), Wu et al. (2023) in their works indicate that automation makes it possible to increase the effectiveness of the general practice of corporate (shown by the example of financial) accounting and reporting.

Based on this, **the hypothesis H₂** is put forward in this article: AI-based automation contributes to the development of corporate accounting and sustainability reporting practices. The economic meaning of the hypothesis put forward is that automation simplifies corporate sustainability accounting and reporting, increasing its accessibility and attractiveness for business and thereby contributing to the popularization of this kind of accounting and reporting. To verify the validity of the hypothesis put forward in this article, the authors carry out econometric modeling of the dependence of the activity of collective accounting and the publication of reports on sustainable development on the factors of artificial intelligence (AI).

3. MATERIALS AND METHODOLOGY

The first task of this study is to determine the importance of corporate sustainability accounting and

reporting for product quality in industry 4.0. It is solved using the regression analysis method, which is used to compile an econometric model of the impact of national rates of sustainability reporting (SustRep, KPMG, 2023; RBC, 2023) on product quality indicators in industry 4.0: 1) medium and high-tech manufacturing value added (Q_{4.0(1)}, World Bank, 2023b) and 2) high-technology exports (Q_{4.0(2)}, World Bank, 2023a). This study is based on a sample of 48 countries for which statistics are available. The time period of the study: 2022. The sample is given in the appendix to the article. The second task is to identify the role of AI-based automation in the development of the practice of corporate sustainability accounting and reporting. It is also solved using the regression analysis method, which is used to compile an econometric model of the influence of the factors of artificial intelligence (AI) on the national rates of sustainability reporting. The following components of "The Global AI Index" (Tortoise Media, 2023) act as the AI factors: talent (AI₁), infrastructure (AI₂), operating environment (AI₃), research (AI₄), development (AI₅), government strategy (AI₆), commercial (investment) (AI₇).

Additionally, a correlation analysis is carried out to clarify the closeness of the connection of the components of "The Global AI Index", in which the regression coefficients will be positive with the national rates of sustainability reporting. The research model has the following form:

$$\begin{cases} Q_{4.0} = \alpha_1 + \beta_1 * \text{SustRep}, \\ \text{SustRep} = a_1 + \sum_{i=2}^n (b_i * \text{AI}_i) \end{cases} \quad (1)$$

The positive values of the regression coefficient β_1 act as confirmation of the hypothesis H₁, and the positive values of the regression coefficients β_i in the model (1) act as confirmation of the hypothesis H₂. To confirm the reliability of the model, Fisher's F-test is performed.

The third task is to reveal the prospects for improving quality in industry 4.0 in countries with emerging practices of corporate sustainability accounting and reporting through the AI-based automation of this practice. To solve it, countries with national rates of sustainability reporting below 50% were selected from the sample. They were 5 countries: Estonia (41%), Israel (43%), Russia (33%), Saudi Arabia (31%) and Turkey (44%).

In accordance with model (1), multicriteria optimization is carried out, which makes it possible to determine the Pareto optimum for each of the selected countries, at which the national rates of sustainability reporting reaches the average value for the sample, namely 81.2%. Using the trend analysis method, the change in indicators compared to their baseline values in 2022 in each of the selected countries is estimated.

The fourth task is to propose a quality management mechanism in industry 4.0, improved through AI-based automation of corporate sustainability accounting and reporting. The mechanism is represented graphically using the formalization method. To substantiate the advantages of the authors' mechanism, management information systems with automation based on datasets and AI are compared with the existing practice of corporate sustainability accounting and reporting using the method of comparative analysis.

4. RESULTS

4.1. The significance of corporate sustainability accounting and reporting for product quality in industry 4.0.

In order to solve the first task of this study and determine the significance of corporate sustainability accounting and reporting for product quality in industry 4.0, the influence of national rates of sustainability reporting on product quality indicators in industry 4.0 has been evaluated using the regression analysis method. The results are reflected in Tables 1-2.

Table 1. The impact of national rates of sustainability reporting on medium and high-tech manufacturing value added

<i>Regression Statistics</i>						
Multiple R		0.3988				
R-Square		0.1591				
Adjusted R-Square		0.1408				
Standard Error		13.8449				
Observations		48				
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	1	1667.9185	1667.9185	8.7015	0.0050	
Residual	46	8817.3783	191.6821			
Total	47	10485.2968				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t-Stat</i>	<i>P-Value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Y-intercept	12.8612	9.3003	1.3829	0.1734	-5.8594	31.5818
National rates of sustainability reporting, %	0.3299	0.1118	2.9498	0.0050	0.1048	0.5551

Source: calculated and compiled by the authors.

The results obtained in Table 1 mean that the influence of national rates of sustainability reporting by 39.88% explains the differences in medium and high-tech manufacturing value added among the sample countries in 2022. The established influence has the following mathematical notation:

$$Q_{4.0(1)} = 12.8612 + 0.3299 * \text{SustRep} \quad (2)$$

According to equation (2), medium and high-tech manufacturing value added rises by 0.3299% of manufacturing value added with an increase in the national rate of sustainability reporting by 1%. The significance of F=0.0050. At the significance level of 0.01, the critical F=7.2200. The observed F=8.7015. Therefore, Fischer's F-test has been passed, and equation (2) is reliably at the significance level of 0.01.

Table 2. The impact of national rates of sustainability reporting on high-technology exports

<i>Regression Statistics</i>						
Multiple R		0.3601				
R-Square		0.1297				
Adjusted R-Square		0.1108				
Standard Error		11.4104				
Observations		48				
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	1	892.5980	892.5980	6.8557	0.0119	
Residual	46	5989.1046	130.1979			
Total	47	6881.7025				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t-Stat</i>	<i>P-Value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Y-intercept	-3.1501	7.6650	-0.4110	0.6830	-18.5789	12.2787
National rates of sustainability reporting, %	0.2414	0.0922	2.6183	0.0119	0.558	0.4269

Source: calculated and compiled by the authors.

The results obtained in Table 2 mean that the impact of national rates of sustainability reporting explains 36.01% of the differences in high-technology exports among the sample countries in 2022. The established influence has the following mathematical notation:

$$Q_{4.0(1)} = -3.1501 + 0.2414 * \text{SustRep} \quad (3)$$

According to equation (3), high-technology exports grow by 0.2414% of manufactured exports with an increase in national rates of sustainability reporting by 1%. The significance of $F=0.0119$. At the significance level of 0.05, the critical $F=4.0517$. The observed $F=6.8557$. Consequently, Fischer's F-test has been passed, and equation (3) is reliably at the significance level of 0.05.0.

Thus, the regression coefficients in equations (2) and (3) have taken positive values and amounted to 0.3299 and

0.2414, respectively. This proves the hypothesis H_1 and means that corporate sustainability accounting and reporting determine the quality of products in industry 4.0, contributing to the growth of: 1) medium and high-tech manufacturing value added; 2) high-technology exports.

4.2. The role of AI-based automation in the development of the practice of corporate sustainability accounting and reporting

In order to solve the second task and identify the role of AI-based automation in the development of the practice of corporate sustainability accounting and reporting, the influence of the factors of artificial intelligence (AI) on the national rates of sustainability reporting has been evaluated using the regression analysis method.

Table 3. The impact of the AI factors on the national rates of sustainability reporting

<i>Regression Statistics</i>						
Multiple R	0.4902					
R-Square	0.2403					
Adjusted R-Square	0.1073					
Standard Error	17.0589					
Observations	48					
<i>ANOVA</i>		<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	7	3681.6814	525.9545	1.8074	0.1126	
Residual	40	11640.2353	291.0059			
Total	47	15321.9167				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t-Stat</i>	<i>P-Value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Y-intercept	74.3005	19.7902	3.7544	0.0006	34.3031	114.2980
Talent	0.1418	0.2266	0.6256	0.5351	-0.3162	0.5998
Infrastructure	-0.1604	0.2714	-0.5910	0.5578	-0.7090	0.3882
Operating Environment	-0.2080	0.2145	-0.9697	0.3380	-0.6415	0.2255
Research	0.0304	0.2076	0.1462	0.8845	-0.3892	0.4500
Development	-0.1972	0.1292	-1.5269	0.1347	-0.4583	0.0638
Government Strategy	-0.9507	0.3961	-2.4003	0.0211	-1.7513	-0.1502
Commercial	1.5812	0.5350	2.9555	0.0052	0.4999	2.6625

Source: calculated and compiled by the authors.

The results obtained in Table 3 indicate that the influence of the AI factors explains 49.02% of the differences in the national rates of sustainability reporting among the sample countries in 2022. The established influence has the following mathematical notation:

$$\text{SustRep} = 74.3005 + 0.1418 * \text{AI}_1 - 0.1604 * \text{AI}_2 - 0.2080 * \text{AI}_3 + 0.0304 * \text{AI}_4 - 0.1972 * \text{AI}_5 - 0.9507 * \text{AI}_6 + 1.5812 * \text{AI}_7 \quad (4)$$

According to equation (4), national rates of sustainability reporting grow by 0.1418% with an increase in talent (AI_1) by 1 point. National rates of sustainability reporting increase by 0.0304% with an improvement of research (AI_4) by 1 point. National rates of sustainability reporting grow by 1.5812% with an

increase in commercial investment (AI_7) by 1 point. Additionally, the correlation analysis has revealed a close relationship between the selected components of "The Global AI Index" and the national rates of sustainability reporting. The correlation is as follows: Additionally, the correlation analysis has revealed a close relationship between the selected components of "The Global AI Index" and the national rates of sustainability reporting. The correlation is as follows: $r_{\text{SustRepAI}_2} = 15.53\%$; $r_{\text{SustRepAI}_4} = 24.17\%$; $r_{\text{SustRepAI}_7} = 29.29\%$.

The other AI factors, in particular, infrastructure (AI_2), operating environment (AI_3), development (AI_5), government strategy (AI_6) do not have a beneficial effect on national rates of sustainability reporting. The significance of $F=0.1126$. At the significance level of

0.15, the critical $F = 1.6485$. The observed $F = 1.8074$. Consequently, Fischer's F-test has been passed, and equation (4) is reliably at the significance level of 0.15. Thus, in equation (4), the regression coefficients for the following factor variables talent (AI_1), research (AI_4) and commercial (investment) (AI_7) have taken positive values. The regression coefficients are 0.1418; 0.0304; 1.5812, respectively. This proves the hypothesis of H_2 and means that AI-based automation contributes to the development of the practice of corporate sustainability accounting and reporting.

4.3. The prospect of improving quality in industry 4.0 in countries with emerging practices of corporate sustainability accounting and reporting through AI-based automation of this practice

In order to solve the third task and reveal the prospects for improving quality in industry 4.0 in countries with emerging practices of corporate sustainability accounting and reporting through AI-based automation of this practice, multicriteria optimization has been carried out in accordance with equations (2)-(4).

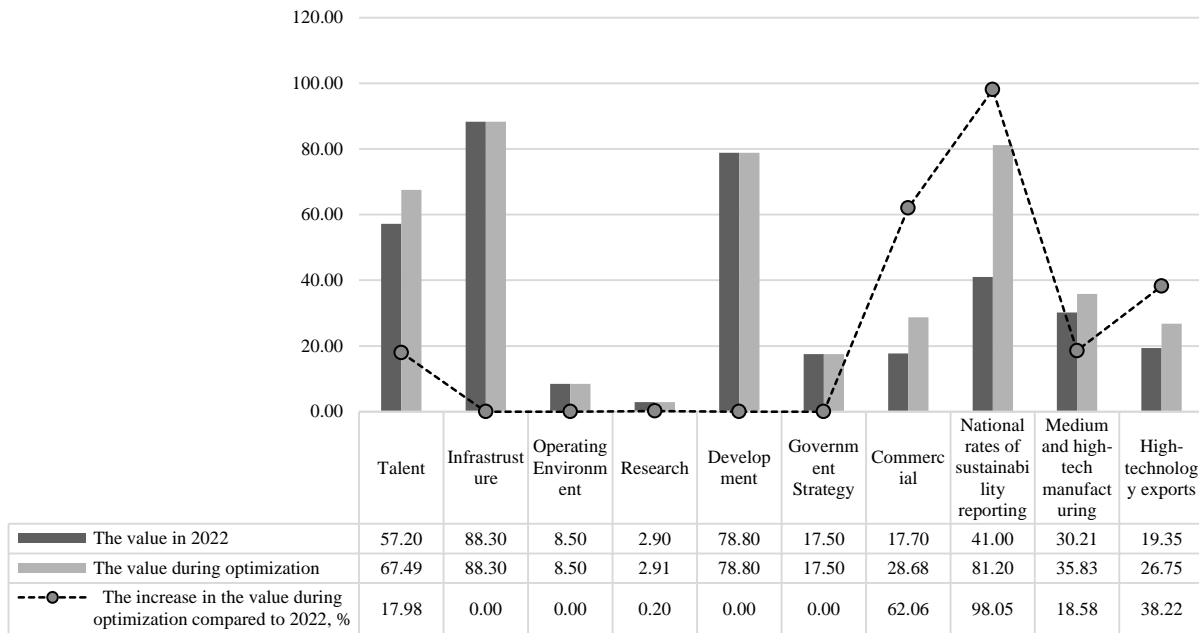


Figure 1. The Pareto-optimum of quality improvement in industry 4.0 in Estonia
 Source: calculated and constructed by the authors.

Based on the Pareto-optimum shown in Fig. 1, the authors' recommendations for increasing the national rates of sustainability reporting in Estonia to the average value for the sample: 81.2%, that is, by 98.05% compared to 2022 (41%) are as follows:

- an increase in talent to 67.49 points, that is by 17.98% compared to 2022 (57.20 points);
- an increase increase in research to 2.91 points, that is, by 0.20% compared to 2022 (2.90 points);
- a growth of commercial investment to 28.68 points, that is, by 62.06% compared to 2022 (17.70 points).

The quality improvement in industry 4.0 through the sustainability of its products in Estonia will lead to:

- an increase in high-technology exports to 35.83% of manufactured exports, that is by

18.58% compared to 2022 (30.21% of manufactured exports);

- a growth of medium and high-tech manufacturing value added to 26.75% of manufacturing value added, that is, by 38.22% compared to 2022 (19.35% of manufacturing value added).

Based on the Pareto-optimum shown in Fig. 2, the authors' recommendations for increasing the national rates of sustainability reporting in Israel to the average value for the sample: 81.2%, that is, by 88.84% compared to 2022 (43%) are as follows:

- an increase in talent to 69.09 points, that is by 14.19% compared to 2022 (60.50 points);
- an increase of research to 22.45 points, that is by 1.12% compared to 2022 (22.20 points);
- a growth of commercial investment to 37.95 points, that is, by 61.48% compared to 2022 (23.50 points).

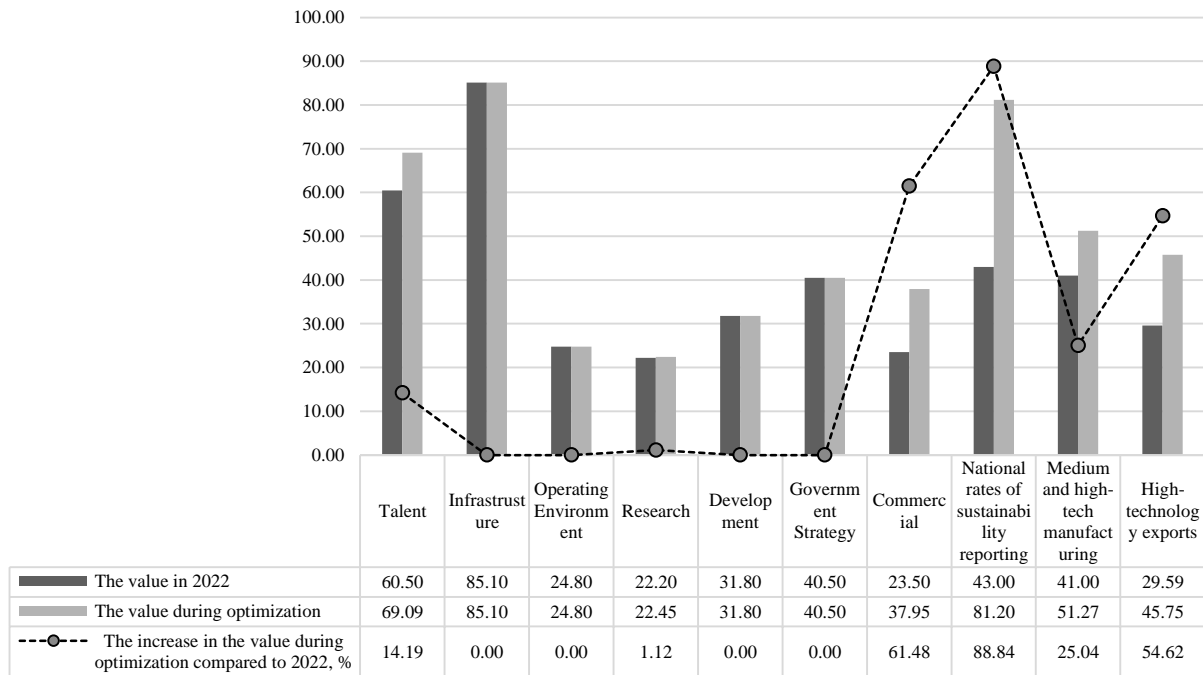


Figure 2. The Pareto-optimum of quality improvement in industry 4.0 in Israel
Source: calculated and constructed by the authors.

The quality improvement in industry 4.0 through the sustainability of its products in Israel will lead to:

- an increase in high-technology exports to 51.27% of manufactured exports, that is by 25.04% compared to 2022 (41% of manufactured exports);
- an increase in medium and high-tech manufacturing value added to 45.75% of manufacturing value added, that is by 54.62% compared to 2022 (29.59% of manufacturing value added).

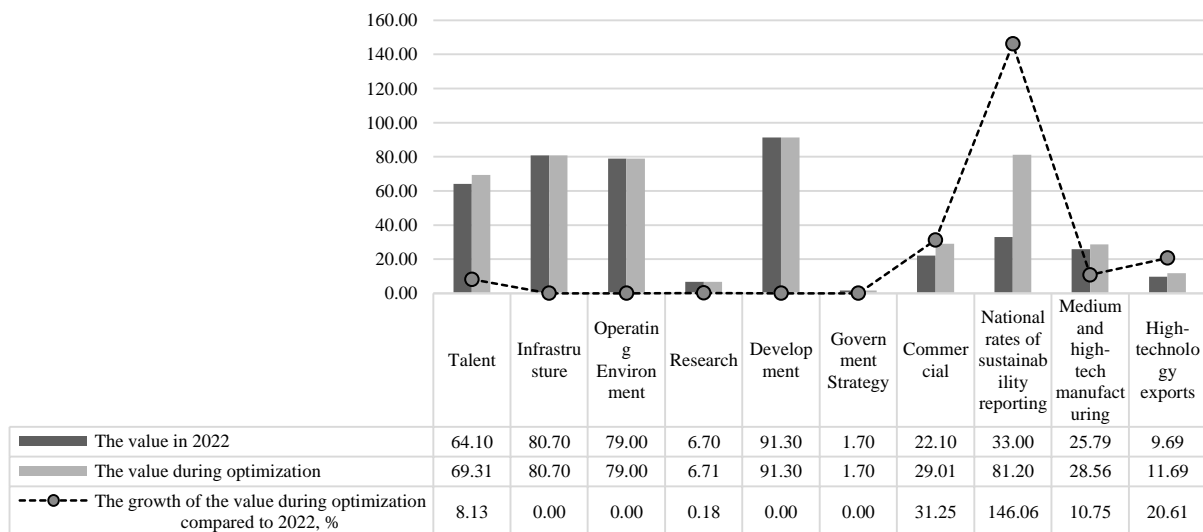


Figure 3. The Pareto-optimum of quality improvement in industry 4.0 in Russia
Source: calculated and constructed by the authors.

Based on the Pareto-optimum shown in Fig. 3, the authors' recommendations for increasing the national rates of sustainability reporting in Russia to the average value for the sample: 81.2%, that is, by 146.06% compared to 2022 (33%) are as follows:

- an increase in talent to 69.31 points, that is by 8.13% compared to 2022 (64.10 points);
- an increase of research to 6.71 points, that is by 0.18% compared to 2022 (6.70 points);
- a growth of commercial investment to 29.01 points, that is, by 31.25% compared to 2022 (22.10 points).

The quality improvement in industry 4.0 through the sustainability of its products in Russia will lead to:

- an increase in high-technology exports to 28.56% of manufactured exports, that is by 10.75% compared to 2022 (25.79% of manufactured exports);

- an increase in medium and high-tech manufacturing value added to 11.69% of manufacturing value added, that is by 20.61% compared to 2022 (9.69% of manufacturing value added).

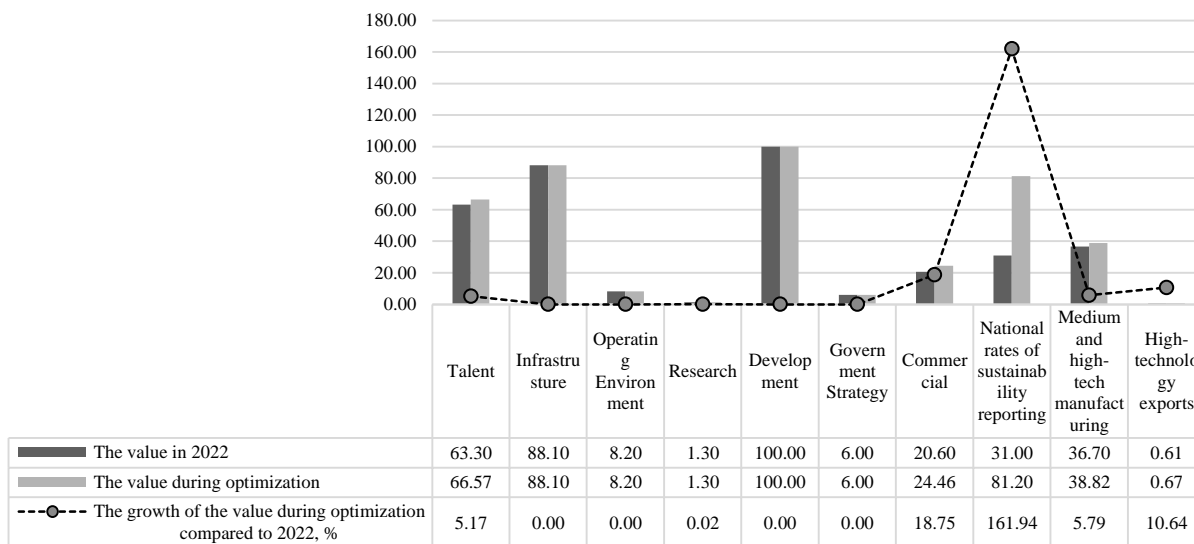


Figure 4. The Pareto-optimum of quality improvement in industry 4.0 in Saudi Arabia

Source: calculated and constructed by the authors.

Based on the Pareto-optimum shown in Fig. 4, the authors' recommendations for increasing the national rates of sustainability reporting in Saudi Arabia to the average value for the sample: 81.2%, that is, by 161.94% compared to 2022 (31%) are as follows:

- an increase in talent to 66.57 points, that is by 5.17% compared to 2022 (63.30 points);
- a growth of commercial investment to 24.46 points, that is, by 18.75% compared to 2022 (20.60 points).

The quality improvement in industry 4.0 through the sustainability of its products in Saudi Arabia will lead to:

- an increase in high-technology exports to 38.81% of manufactured exports, that is, by 5.79% compared to 2022 (36.70% of manufactured exports);
- an increase in medium and high-tech manufacturing value added to 0.67% of manufacturing value added, that is, by 10.64% compared to 2022 (0.61% of manufacturing value added).

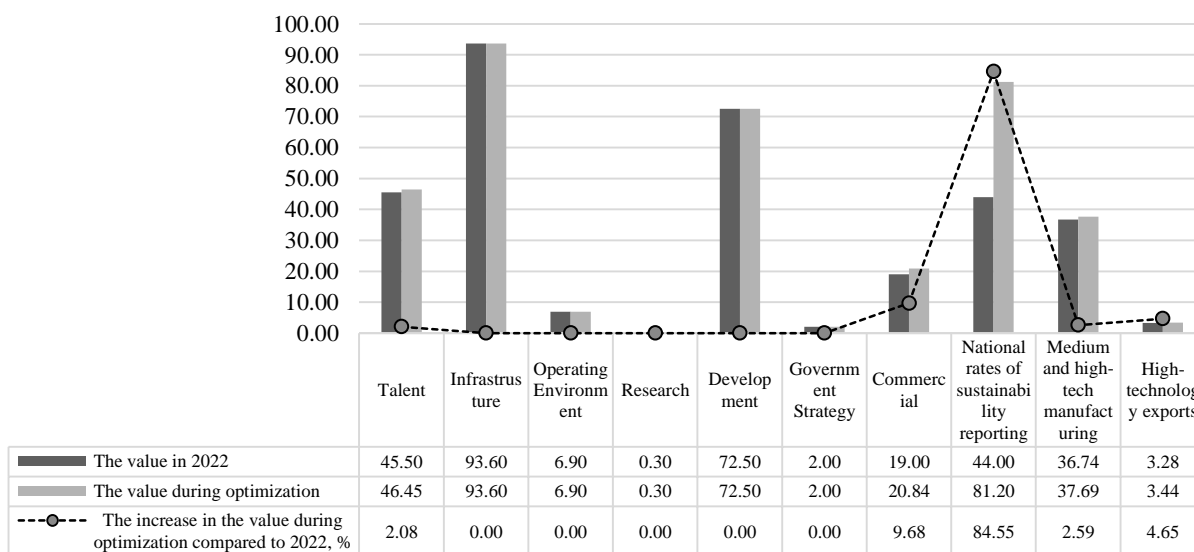


Figure 5. The Pareto-optimum of quality improvement in industry 4.0 in Turkey

Source: calculated and constructed by the authors.

Based on the Pareto-optimum shown in Fig. 5, the authors' recommendations for increasing the national rates of sustainability reporting in Turkey to the average value for the sample: 81.2%, that is, by 84.55% compared to 2022 (44%) are as follows:

- an increase in talent to 46.45 points, that is, by 2.08% compared to 2022 (45.50 points);
- a growth of commercial investment to 20.84 points, that is, by 9.68% compared to 2022 (19 points).

The quality improvement in industry 4.0 through the sustainability of its products in Turkey will lead to:

- an increase in high-technology exports to 37.69% of manufactured exports, that is, by 2.59% compared to 2022 (36.74% of manufactured exports);
- an increase of medium and high-tech manufacturing value added to 3.44% of

manufacturing value added, that is, by 4.65% compared to 2022 (3.28% of manufacturing value added).

Thus, the proposed authors' recommendations will help to overcome the gaps and reach the global average

4.4. Quality management mechanism in industry 4.0, improved through automation based on datasets and AI of corporate sustainability accounting and reporting

To solve the fourth task, the authors, based on the results of regression analysis, have developed a quality management mechanism in industry 4.0, improved through automation based on datasets and AI of corporate accounting and reporting on sustainable development.

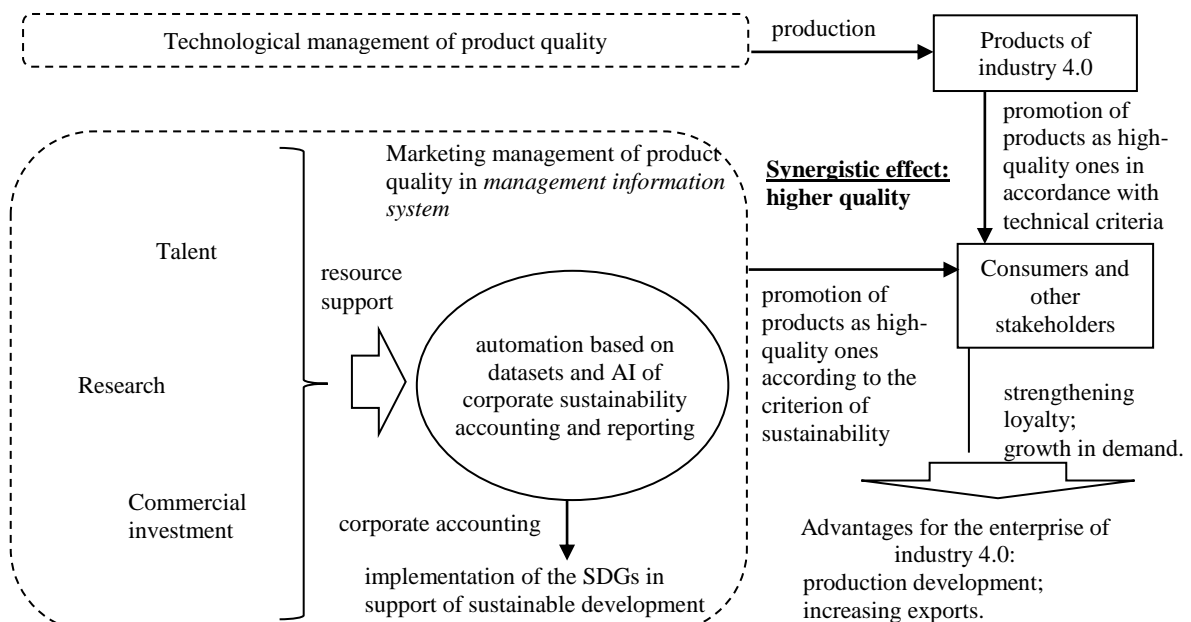


Figure 6. The improved mechanism of quality management in industry 4.0

Source: developed by the authors.

In the authors' mechanism presented in Fig. 6, by analogy with the existing mechanism, technological management of product quality ensures the production of products in industry 4.0. They are promoted on the market as high-quality ones according to technical criteria, that is, corresponding to Quality 4.0.

Along with this, marketing quality management of products is carried out in the management information system. The SDGs are implemented in support of sustainable development. Talent, research and commercial investment in AI provide resource support. With its help, automation based on datasets and AI of corporate sustainability accounting and reporting takes place. This ensures the sustainability of the products – this quality is emphasized when they are promoted on the market.

The mix of Quality 4.0 and sustainability through the combination of technological and marketing management generates a synergistic effect expressed in higher product quality than when these management practices are carried out separately. Due to the synergetic effect, the loyalty of consumers and other stakeholders to the products of the enterprise of industry 4.0 is strengthened and the demand for them increases. The final advantages for the enterprise of industry 4.0 are associated with the development of production and the increase in exports of products of industry 4.0.

The core of the developed mechanism is management information systems, improved through automation based on datasets and AI. Their comparison with the existing practice of corporate sustainability accounting and reporting is presented in Table 4.

Table 4. Comparison of management information systems in automation based on datasets and AI with the existing practice of corporate sustainability accounting and reporting

Organizational and technical aspects of management information systems		Implementation of aspects in corporate sustainability accounting and reporting	
		In the existing practice	In automation based on datasets and AI
Monitoring and corporate accounting	Primary data collection	department heads perform manually as an additional workload	AI here and below
	Polycriteria assessment	the sustainability manager performs manually here and below: fragmentary	complete, highly accurate, standardized
Formation of corporate reporting	Creating the main (short) report	text report with infographic elements	interactive report with explanations on request
	Creating an explanation: an extended report	not provided	dataset: provided interactively at the request of users
Information support for corporate reporting	Publication of the report	manually on the company’s website	automatically on the company’s website and the websites of rating agencies
	Communication with stakeholders about the report	not provided	they are carried out automatically via a chatbot

Source: developed by the authors.

As shown in Table 4, with automation based on datasets and AI, all organizational and technical aspects of management information systems differ from the existing practice of corporate sustainability accounting and reporting and, due to the highlighted differences, make this practice more effective.

Firstly, during monitoring and corporate accounting, the collection of primary information on the implementation of the SDGs at the enterprise is carried out not by department heads (as an additional workload and manually), but by artificial intelligence (AI). In other processes, the subject of management is not the sustainability manager (manually), but AI (automatically). Polycriteria assessment of the sustainability of the company’s products is not fragmented, but complete, highly accurate and standardized.

Secondly, when forming corporate reporting, the creation of the main (short) report does not involve a text report with infographic elements, but an interactive

report with explanations on request. In automation based on datasets and AI, an explanation is also created: a dataset provided interactively at the request of users.. Thirdly, with the information support of corporate reporting, the report is published not manually on the company’s website, but automatically on the company’s website and the websites of rating agencies. In automation based on datasets and AI, communications with stakeholders about the report are also carried out - automatically via a chatbot.

5. DISCUSSION

The contribution of the article to the literature is the development of the theory of product quality management through the improvement of the approach to product quality management in industry 4.0, for which automation based on datasets and AI of corporate sustainability accounting and reporting has been proposed. The received answers to the RQs are presented in Table 5 in comparison with the literature.

Table 5. Received answers to the RQs in comparison with the existing literature

Research questions (RQs)	Answers to the RQs	
	Available answers in the existing literature	New answers received in this article
RQ1: What is the impact of corporate accounting and sustainability reporting on product quality in industry 4.0?	Corporate sustainability accounting and reporting do not affect the quality of products in Industry 4.0 – neither the volume of its production nor the scale of exports (Dias Lopes et al., 2023; Khan et al., 2023)	Corporate sustainability accounting and reporting determine the quality of products in industry 4.0, contributing to the growth of (correlation): <ul style="list-style-type: none"> • Medium and high-tech manufacturing value added: 39.88%; • High-technology exports: 36.01%.
RQ2: What is the contribution of AI-based automation to the development of corporate accounting and sustainability reporting practices?	Corporate sustainability accounting and reporting are specific and therefore are not subject to automation (Dumitru et al., 2023; Matthies, 2020)	AI-based automation contributes to the development of the practice of corporate sustainability accounting and reporting, a key role in this is played by (correlation): <ul style="list-style-type: none"> • Talent: 15.53%; • Research: 24.17%; • Commercial investment: 29.29%.

Source: developed by the authors.

As shown in Table 5, unlike Dias Lopes et al. (2023), Khan et al. (2023), corporate accounting and sustainability reporting determine product quality in industry 4.0, contributing to the growth of (correlation): medium and high-tech manufacturing value added: 39.88% and high-technology exports: 36.01% (the hypothesis H₁ has been confirmed).

In contrast to Dumitru et al. (2023), Matthies (2020), despite the specificity of corporate sustainability accounting and reporting, they, as well as financial accounting and reporting, are subject to automation. AI-based automation contributes to the development of corporate sustainability accounting and reporting practices (the hypothesis H₂ has been confirmed). The key role in this is played by (correlation): talent: 15.53%, research: 24.17% and commercial investment: 29.29%.

6. CONCLUSION

So, the article has substantiated the expediency and developed recommendations for automation based on datasets and AI of corporate sustainability accounting and reporting. The key conclusion is that automation based on datasets and AI of corporate sustainability accounting and reporting can improve the quality of products in industry 4.0. In particular, based on international empirical experience for 2022 and official statistics, the following main results have been obtained. Firstly, the significance of corporate sustainability accounting and reporting for product quality in industry 4.0 has been revealed. Thus, the impact of national rates of sustainability reporting determines medium and high-tech manufacturing value added by 39.88% and high-technology exports – by 36.01%. Secondly, the significant role of AI-based automation in the development of the practice of corporate sustainability accounting and reporting has been substantiated.

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Together, AI factors determine the national rates of sustainability reporting by 49.02% in 2022. The key of these factors are: talent: 15.53%, research: 24.17% and commercial investment: 29.29%.

The theoretical significance lies in the fact that the article has clarified the structure of product quality of industry 4.0. In addition to Quality 4.0, a new quality component has been highlighted: product sustainability, the achievement of which depends not only on the implementation of the SDGs by the business, but also on the effectiveness of its management information systems. The central role of the effectiveness of management information systems in quality management of products in industry 4.0 to achieve their sustainability has also been substantiated.

The practical significance is related to the fact that the article has revealed the prospects (Pareto-optima) and proposed the authors' recommendations for improving quality in industry 4.0 in countries with emerging practices of sustainability accounting and reporting – Estonia, Israel, Russia, Saudi Arabia and Turkey – through AI-based automation of this practice. The mathematical models obtained and presented in the article can be used to reveal prospects and develop recommendations in other countries of the world.

The managerial significance is expressed in the fact that the developed authors' mechanism will improve the practice of quality management in industry 4.0 through automation based on datasets and AI of corporate sustainability accounting and reporting. The advantage of the improved mechanism is the higher effectiveness of management information systems of enterprises in industry 4.0, which contributes to the expansion of their production and development of exports due to the growth of loyalty of stakeholders and an increase in sales.

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