

RESPONSIBLE HRM IN THE QUALITY MANAGEMENT SYSTEM AT ENTERPRISES OF INDUSTRY 4.0 IN RUSSIA

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ABSTRACT

The purpose of this article is to determine the place of responsible HRM in the quality management system at enterprises of industry 4.0 in Russia, as well as to identify prospects and develop recommendations for improving the Russian model of this management. The study of Russia's experience for 2021-2023 based on the statistics of the stock indices of the Moscow Stock Exchange using the regression analysis method has revealed that corporate social responsibility stimulates the development of enterprises in industry 4.0 (proved by the example of telecommunications). Based on statistical data for 2018-2021, a significant contribution of responsible personnel management to improving the efficiency of quality management of Russian enterprises in industry 4.0 was substantiated using correlation analysis. As a result, an improved quality management model of enterprises in industry 4.0 based on responsible HRM has been developed, which has identified key management practices and advantages of responsible HRM at each stage of the innovation process. The main conclusion based on the results of the study is that responsible HRM occupies a central place in the quality management system at enterprises of industry 4.0 in Russia. The contribution of the article to the literature is that it opens up a new perspective on the prospects for improving the quality management at enterprises in industry 4.0 – with the help of responsible HRM. The article describes these prospects in detail on the example of Russia and offers applied recommendations taking into account the specifics of the Russian HR model of quality management at enterprises of industry 4.0. The practical significance of the authors' conclusions and developments is that they make it possible to realize the potential of improving product quality of industry 4.0 in Russia in the "Decade of Action".



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1. INTRODUCTION

Industry 4.0 is a high-tech area of the digital economy with an increased concentration of ICT and high activity in the creation and implementation of innovation and advanced technologies (Sharma, 2023). Industry 4.0 is distinguished from other areas of the digital economy by the advanced introduction of technologies, as well as the highest product complexity (Handayani et al., 2022). These distinctive features determine the specifics of the interpretation and quality management in the activity of enterprises in industry 4.0, which consists in the fact that ICT, innovation and high technologies are of paramount importance for quality (Nwasuka et al., 2022).

The reason for this is that the value of industry 4.0 products for consumers lies in its high-tech and innovative nature, which supports the digital competitiveness of the economy (Irina et al., 2019). Low innovation activity combined with the slow pace of the introduction of ICT and high technologies lead to a gradual decline in product quality, and in the strategic perspective – to crowding out of enterprises from industry 4.0 (Matkovskaya, 2022). In the context of the Fourth Industrial Revolution, the boundaries of industry 4.0 are constantly changing, but it has invariably been the locomotive of scientific and technological progress (Dyakov et al., 2022).

The delayed introduction of ICT, innovations and high technologies reduces the global competitiveness of Industry 4.0 products, which in this case is inevitably replaced by foreign analogues and forced out of target markets (Sergi and Popkova, 2022). Therefore, the product quality of enterprises in industry 4.0 is crucial for ensuring the technological sovereignty of the digital economy, its growth and development (Popkova and Sergi, 2023; Popkova, 2023). HR quality management at enterprises in Industry 4.0 deserves special attention and special research for the following two reasons.

The first reason is the contradictory role that human resources play in the management of product quality at enterprises of industry 4.0. On the one hand, creative personnel generate innovations and master new technologies. On the other hand, innovations can be acquired by enterprises of industry 4.0 externally, in particular, from research institutes and R&D universities. At the same time, automation, typical for industry 4.0, reduces the need for human resources – their functions are subject to automation, including those related to the introduction of innovations and the organization of high-tech industries.

The second reason is that the priority of the economy in the “Decade of Action” is sustainable development – and industry 4.0 is no exception. The meaning of sustainable development is the systematic implementation of the 17 UN SDGs (Sustainable

Development Goals). In this regard, the isolated implementation of SDG9 (through the development of telecommunications infrastructure and the introduction of innovations in industry 4.0) is not sufficient. In the HRM aspect, it is worth noting that the sustainable development of industry 4.0 also involves support for employment and promotion of the disclosure of human potential to achieve the growth of the digital economy (SDG8).

The above determines the relevance of studying the scientific and practical problem associated with identifying the extent of compliance of HR-related quality management of product quality in the activities of enterprises of industry 4.0 with the principles of corporate social responsibility. The existing literature only fragmentally reveals the practical experience of HR-related product quality management in the activities of enterprises in industry 4.0 and offers a number of alternative models of this management. The Russian experience of this management is poorly studied, which is why the essence and prospects for improving HR-related product quality management in the activities of enterprises of industry 4.0 in the Russian model of this management are not clear. This is a gap in the literature that this article fills.

The purpose of this article is to determine the place of responsible HRM in the quality management system at Russian enterprises of industry 4.0, as well as to identify prospects and develop recommendations for improving the Russian model of this management. The originality of the research conducted in this article is due to the fact that it rethinks the essence of quality management in industry 4.0 from the standpoint of HRM, and also reveals previously unknown features of the Russian model of this management.

The contribution of the article to the literature is that it opens up a new perspective on the prospects for improving the quality management at enterprises in industry 4.0 – with the help of responsible HRM. These prospects are described in detail in the article on the example of Russia and are supported by applied recommendations taking into account the specifics of the Russian HR model of quality management at enterprises in industry 4.0.

The purpose is achieved by solving the following tasks. The first task is to study the experience and prospects for the development of enterprises of industry 4.0 on the basis of corporate social responsibility in Russia. The second task is to determine the contribution of responsible HRM to improving the effectiveness of quality management at enterprises of industry 4.0. The third task is related to the development of an improved model of quality management at enterprises in industry 4.0 based on responsible HRM.

2. LITERATURE REVIEW AND GAP ANALYSIS

2.1. HR models of quality management at enterprises of industry 4.0 based on international experience

The scientific basis of this study is determined by the provisions of the Theory of HR-related quality management in entrepreneurship (Nan et al., 2023; Papademetriou et al., 2023). In accordance with this theory, alternative models of HR-related product quality management at enterprises of industry 4.0 have been developed in international economic practice. Among them, it is worth paying attention to two models with clearly defined contours and fundamentally different from each other.

The first model is typical for developed countries and, in particular, is implemented in OECD countries. Corporate quality control plays a key role in this model. High-tech startups and multinational corporations of industry 4.0 are the leaders who set the tone for global competition in their target markets, forming their own corporate quality standards. The production process is designed in such a way as to ensure its transparency, strict adherence to quality standards and its full control. At the same time, products that do not comply with the current corporate quality standards are considered defective and are not sold on the market (Portalanza-Chavarría and Revuelto-Taboada, 2023).

In the process of selling industry 4.0 products, when promoting them, the emphasis is on their high quality, which forms the basis of their competitiveness. With the help of patented innovations and advanced technologies, companies strive to gain unique competitive advantages in the field of product quality in industry 4.0. The products are distributed under licensing and franchise conditions through the branch network of multinational corporations. Quality growth is stimulated by a market mechanism (Gong et al., 2023).

From the HRM perspective, the model under consideration assumes a strict and careful selection of the best personnel – attracting them from all over the world and retaining them through the creation of knowledge-intensive, high-performance and high-paying jobs and broad career opportunities (Fregnan et al., 2020).

However, the reduction of quality risks associated with the influence of the “human factor” and the complexity of industry 4.0 products is associated with intensive robotization of its production. Automation leads to a large-scale reduction in the number of employees of companies in industry 4.0. In this process, there is a thorough screening and selection of the best personnel who represent the greatest value for companies – with the greatest human potential in terms of digital competencies and creative abilities (Kaushal et al.,

2023). They are provided with comfort in the workplace and generally favorable employment conditions, with the exception of psychological pressure associated with high risks of their reduction along with further automation (van der Straaten et al., 2023).

The second model is typical for developing countries and, in particular, is implemented in China and India. In this model, it is common practice to conclude long-term contracts for the production and supply of industry 4.0 products in large wholesale lots to take advantage of the “economies of scale”. The fixed price of industry 4.0 products specified in the contract is not subject to change. This limits the influence of the market mechanism on production and distribution processes in the model under consideration. With an increase in production costs, as well as a general increase in market prices, manufacturers supply products of industry 4.0 in volume and at a price in accordance with the contract, but sometimes at the expense of quality (Joseph et al., 2023).

The decrease in quality occurs in an effort to reduce the cost of production in order to avoid losses. Quality control is not strict and has a superficial character. Even if the product quality requirements are specified in the contracts, they may be violated, which may lead to the supply of defective products unsuitable for use. In order to increase the global competitiveness of products, not only own, but also borrowed innovation and technologies are introduced into production.

From the standpoint of HRM, the model under consideration assumes high demands on labor productivity, while employment may involve hard labor with insufficient comfort in the workplace and limited opportunities to unlock human potential and build a career (Ma et al., 2023). Robotization of production in industry 4.0 is actively implemented. However, to reduce the cost of production, less expensive manual labor is often preferable (Pizzolitto et al., 2023; Yuan et al., 2022).

Thus, both described models do not fully comply with the principles of corporate social responsibility in HRM in the activities of enterprises in industry 4.0. The model of developed countries opens up wide opportunities for the manifestation of creativity of workers, but does not guarantee their employment. In contrast, the model of developing countries is more focused on labor productivity than on product quality, and therefore human resources are used to fully utilize the production capacity at enterprises of Industry 4.0. In this model, jobs are created and employment is fairly stable (guaranteed), but with limited opportunities for creativity.

2.2. The HR-model of quality management at enterprises of industry 4.0, which has developed in Russia: a historical overview and a critical look

State standardization of quality (GHOST) is historically characteristic of Russia. In modern conditions of a market economy, compliance with GOST is often the basis for the competitive advantages of industry 4.0 products (Matytsin and Rusakova, 2021; Popkova, 2019). From the standpoint of HRM, the Russian model assumes a low importance of human resources for quality management at enterprises in industry 4.0. This is due to the fact that the quality of these products is determined by technological resources.

Human resources are perceived as largely interchangeable (Karanina et al., 2022). The wide availability of highly qualified human resources, including digital personnel, causes their high competition and, accordingly, greater power of buyers in the labor market (Denisov et al., 2018). This limits employment opportunities, reduces the price of labor and eliminates market incentives for employers to retain staff (Degtyarova et al., 2016).

The approach to HR-related quality management at enterprises in industry 4.0 due to active automation is associated with the release of personnel and the transfer of the remaining employees to the maintenance of automation equipment (Sozinova and Saveleva, 2022). Quality control of industry 4.0 products is carried out systematically and involves the rejection of defective products that do not meet quality standards (both GOST and corporate standards, if any) (Pankina, 2015). This demonstrates the similarity of the Russian model with the model typical for developed countries.

Thus, the presented critical look at the Russian model of HR-model of quality management at enterprises of industry 4.0 shows that it does not comply with the principles of corporate social responsibility in HRM in the activities of enterprises of industry 4.0.

The conducted literature review has shown that responsible HRM is not integrated into the existing HR-model of quality management at enterprises of industry 4.0 in Russia, which is based on personnel substitution, since it assumes the interchangeability of human resources and their secondary role in quality management in comparison with technological resources.

2.3 The concept of responsible HRM, RQ and the research hypothesis

The scientific provisions of the concept of responsible HRM are given in the works of such authors as Wang and Shaheryar (2020), Yang et al. (2023). The concept of responsible HRM involves the implementation of SDG8 through the creation of additional jobs and the

guarantee of stable employment, increasing the comfort of workplaces, retaining personnel through the corporate system of incentives for labor stimulation, providing favorable conditions for the disclosure of human potential and career building.

Among the promising practices of responsible HRM, potentially supporting the improvement of product quality in industry 4.0, it is worth noting the following:

- Creation of knowledge-intensive jobs (Yousaf and Palazzo, 2023);
- Provision of employment opportunities for young people as the most flexible, talented and creative personnel (Federici et al., 2023);
- Guarantee of full protection of workers' labor rights and freedom of work (Mohanan and Rajarathinam, 2023);
- Provision of employment opportunities for highly qualified personnel (with advanced education) (Choudhary and Kunte, 2023);
- Introduction of social innovations to improve employment conditions for the benefit of workers (Kersten et al., 2023; Shaji et al., 2023).

The following are the target results of quality management of Industry 4.0 enterprises, which can potentially be improved through responsible HRM:

- Improvement of research and development results (Saihi et al., 2023);
- Increase in the number of patent applications in the field of ICT (Dohale et al., 2023);
- Extension of the influence of ICT on business models (Singh et al., 2022);
- Development of trade in both high technologies and high-tech products (Moraes et al., 2023);
- Improvement of the quality of research institutes (Alam and Dhamija, 2022);
- Technological learning at the business level (Jain and Jain, 2022);
- Attraction and enhancement of the activity and success of the introduction of the latest (advanced) technologies (Flores et al., 2020; Souza et al., 2022).

Based on the results of the literature review, it has been established that the implications of responsible HRM for the quality of enterprises in industry 4.0 are insufficiently studied and therefore are uncertain. This is a gap in the literature that this article seeks to fill. It poses the following research question. RQ: What is the place of responsible HRM in the quality management system of Russian enterprises in industry 4.0?

Based on the works of Dhaigude et al. (2023), Ting et al. (2023), Urbaniak & Zimon M. (2023). which noted the advantages of responsible HRM in the form of improving the product quality at enterprises of industry

4.0 using examples from international experience, this article suggests that these advantages can be obtained in Russia as well.

In this regard, the article puts forward hypothesis H that the implementation of responsible HRM practices contributes to increasing the target results of quality management of Russian enterprises in industry 4.0. To test the hypothesis put forward, the authors conduct an econometric analysis of the relationship of the noted practices of responsible HRM with the listed target results of quality management at enterprises of industry 4.0 in Russia.

3. MATERIALS AND METHODOLOGY

When solving each of the three tasks of this study, the appropriate methodological apparatus is used. The first task is to systematize the experience and identify the prospects for the development of enterprises in industry 4.0 based on corporate social responsibility in Russia. To solve it, the regression analysis method is used, through which the authors model the dependence of the Telecommunications Industry Index (MOEX, 2023b, we introduce the designation: Telecom4.0) on the “Responsibility and Openness” index (MOEX, 2023a, official designation: MRRT).

Both studied indices are calculated by the Moscow Stock Exchange and compiled on the basis of data on Russian companies. The time frame of the study covers the last two years: the period from 05/26/2021 to 05/26/2023. The values of the indices by day (488 observations) are given in the appendix to this article. The research model has the following form:

$$\text{Telecom4.0} = a + b * \text{MOEX} \quad (1)$$

The reliability of the model (1) is checked using the model error analysis, correlation analysis, Fisher’s F-test and Student’s t-test. Based on the model (1), a change in the capitalization of the Telecommunications Industry Index is predicted with an increase in the capitalization of the “Responsibility and Openness” index: until the end of 2023, as well as in the “Decade of Action” (until 2030).

The second task is to determine the contribution of responsible HRM to improving the effectiveness of quality management of enterprises in industry 4.0. Its solution is carried out using the method of correlation analysis, which determines the relationship of responsible HRM practices with the results of quality management at enterprises of industry 4.0 in Russia in 2018-2021, based on Knoema statistics (2023).

Responsible HRM practices are studied based on the following indicators: high-skilled employment (% of total employed people), youth not in employment, education or training (%), labor freedom, unemployment rate with advanced education, as well as outputs of societal innovation. The results of quality

management at enterprises in industry 4.0 are measured using the following indicators: research and development outputs, ICT PCT patent applications (per 100 billion GDP), impact of ICTs on business models, high-technology trade (% total trade), quality of research institutions, firm-level technology absorption, as well as availability of latest technologies.

All these indicators are measured in points from 1 to 100 (best). The final contribution of the responsible HRM to the achievement of quality management results at enterprises in industry 4.0 is determined by the following formula:

$$I_{\text{HRM4.0}} = \text{Cor} * \text{Sc}, \quad (2)$$

where $I_{\text{HRM4.0}}$ – the final contribution of the responsible HRM to achieving the results of quality management of at enterprises in industry 4.0, %;

Cor – arithmetic average of positive correlation coefficients, %;

Sc – the proportion of positive correlation coefficients (the proportion of 1).

Hypothesis H is recognized as proven in the case of a positive value of the coefficient b in the model (1) and its statistical significance (reliability), as well as with the final contribution of the responsible HRM to achieving the results of quality management at enterprises of industry 4.0 in Russia exceeding 15%. The third task is to develop an improved quality management model for enterprises in industry 4.0 based on responsible HRM. The model is developed using the results of correlation analysis. It is presented graphically with the help of the formalization method.

4. RESULTS

4.1. Development of enterprises in industry 4.0 on the basis of corporate social responsibility: experience and prospects of Russia

To solve the first problem related to the systematization of experience and the identification of prospects for the development of enterprises in industry 4.0 based on corporate social responsibility in Russia, a regression analysis of data from the table attached to this article was carried out. The dependence of the capitalization of the Telecommunications Industry Index on the capitalization of the “Responsibility and Openness” index in accordance with the research model (1) is mathematically described by the following econometric model (3):

$$\text{Telecom4.0} = 1135061349 + 0,0074 * \text{MOEX} \quad (3)$$

Based on model (3), the capitalization of the Telecommunications Industry Index rises by 0.0074 rubles with an increase in the capitalization of the “Responsibility and Openness” index by 1 rubles. The reliability of the model (3) is checked in Table 1.

Table 1. Checking the reliability of the model (3)

| Elements of analysis | | |
|---|------------------------------|---------------------------|
| Regression statistics | Multiple R (determination) | 0,7126 |
| | R-Square | 0,5078 |
| | Adjusted R-Square | 0,5067 |
| | Observations | 488 |
| Analysis of variance and Fischer's F-test | Number of degrees of freedom | 487 |
| | Significance of F | 8,01495*10 ⁻⁷⁷ |
| | Significance level | 0,001 (error: 0,1%) |
| | Critical F* | 10,9605 |
| | Observed F | 501,3214 |
| | Fischer's F-test | Passed (501,3214>10,9605) |
| Regression characteristics for the factor variable (MRRT) | Standard error | 0,0003 |
| | t-critical | 2,5859 |
| | t-observed | 22,3902 |
| | Student's t-test | Passed (22,3902>2,5859) |

*when $k_1=m=1$, $k_2=n-m-1=488-1-1=486$.

Source: calculated and compiled by the authors.

The results from Table 1 indicate that the change in the capitalization of the Telecommunications Industry Index by 71.26% (multiple R=0.7126; R2=0.5078) is explained by the change in the capitalization of the "Responsibility and Openness" index in 2021-2023. The standard error tends to zero and is 0.0003. Fischer's F-test and Student's t-test have been passed at the highest level of significance: 0.001, therefore, model (3) is reliable, and its error does not exceed 0.1%.

Based on model (3), the authors have made a forecast of changes in the Telecommunications Industry Index with an increase in the "Responsibility and Openness" index. The authors' forecast takes into account the crisis context of 2021-2023 in the international and Russian economy. Therefore, the forecast until the end of 2023

is based on the actual growth of the "Responsibility and Openness" index for the period from 16.02.2023 to 26.05.2023, when the capitalization of this index increased. Its growth is estimated at 1.18 times: from 24528610869400.30 rubles (16.02.2023) to 29010052389471.40 rubles (26.05.2023).

The forecast for the period of the "Decade of Action" (until 2030). When making it, the authors took as a basis the maximum value of the "Responsibility and openness" index in the time series: 53421624256769.40 rubles, which was observed on 21.10.2021. The indicated values of the factor variable were substituted into the model (3), which made it possible to predict the consequences for the Telecommunications Industry Index (Fig. 1).

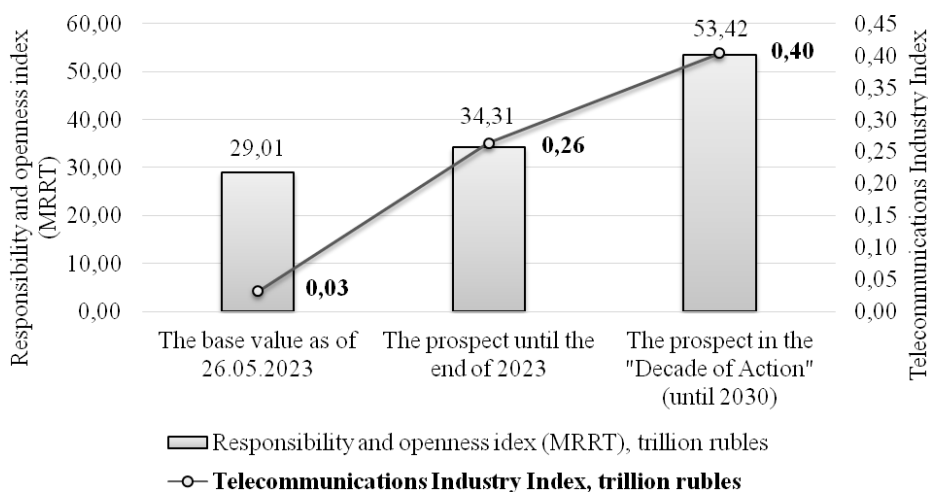


Figure 1. Prospects for the development of enterprises in industry 4.0 based on corporate social responsibility

Source: calculated and constructed by the authors.

The forecast results from Figure 1 mean that in the short term (until the end of 2023), the capitalization of the Telecommunications Industry Index may increase by 8.36 times due to the growth of the capitalization of the "Responsibility and Openness" index by 1.18 times. In the long term (in the "Decade of Action": until 2030), the capitalization of the Telecommunications Industry

Index may increase by 12.84 times due to the growth of the capitalization of the "Responsibility and Openness" index by 1.84 times. This proves significant prospects for the development of enterprises of industry 4.0 on the basis of corporate social responsibility in Russia.

4.2. The contribution of responsible HRM to improving the effectiveness of quality management at enterprises in industry 4.0

To solve the second task, which is to determine the contribution of the responsible HRM to improving the

effectiveness of quality management at enterprises in Industry 4.0, a correlation analysis of the data in Tables 2-3 was carried out. The review and cross-correlation of responsible HRM practices in Russia in the dynamics of 2018-2021 are conducted in Table 2.

Table 2. Review and cross-correlation of responsible HRM practices in Russia in the dynamics of 2018-2021, points 1-100

| Indicators | | High-skilled employment (% of total employed people) | Youth not in employment, education or training (%) | Labour freedom | Unemployment rate with advanced education | Outputs of societal innovation |
|----------------------|--|--|--|----------------|---|--------------------------------|
| Values, points 1-100 | 2018 | 69,30 | 74,40 | 52,00 | 83,80 | 26,60 |
| | 2019 | 75,50 | 78,10 | 38,90 | 74,40 | 21,00 |
| | 2020 | 71,50 | 85,80 | 38,60 | 86,50 | 25,10 |
| | 2021 | 71,50 | 72,90 | 38,60 | 84,90 | 27,50 |
| Cross-correlation, % | High-skilled employment | 100,00 | - | - | - | - |
| | Youth not in employment, education or training | 19,43 | 100,00 | - | - | - |
| | Labour freedom | -66,80 | -39,54 | 100,00 | - | - |
| | Unemployment rate with advanced education | -83,08 | 14,22 | 15,05 | 100,00 | - |
| | Outputs of societal innovatio | -87,97 | -36,38 | 34,08 | 87,03 | 100,00 |

Source: compiled by the authors based on the materials of Knoema (2023).

As the results of the correlation analysis in Table 2 show, there is no multicollinearity of indicators statistically describing the practices of responsible HRM, since none of the correlation coefficients exceeds 90%. The results of quality management of enterprises in industry 4.0 in 2018-2021 and the correlation analysis of the relationship with the practices of responsible HRM are shown in Table 3 (see Appendix).

The results obtained in Table 3 indicate that the final contribution of the responsible HRM to the achievement of quality management results of enterprises in industry 4.0 (IHRM4.0) was 24.70%. The results of the correlation analysis are shown in more detail in Fig. 2-3.

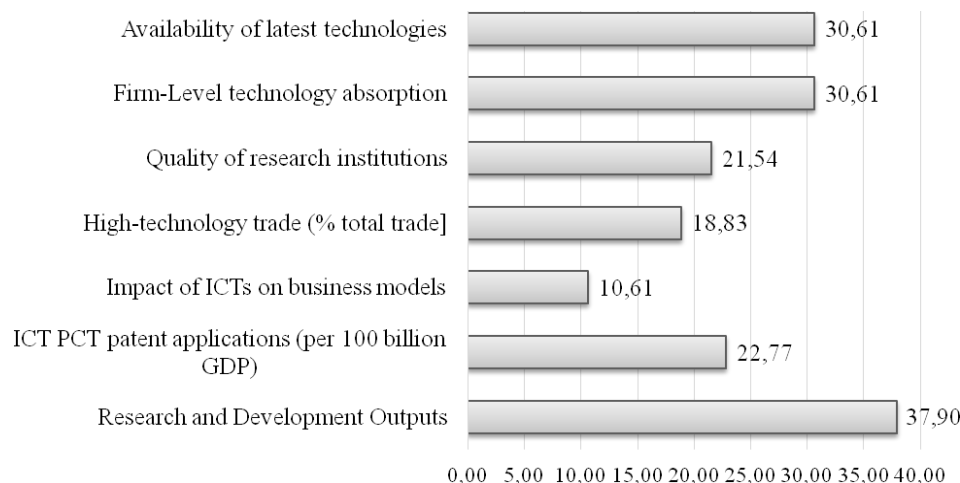


Figure 2. Contribution of responsible HRM to improving the quality management results of enterprises in industry 4.0, %

Source: calculated and constructed by the authors.

According to Fig. 2, the responsible HRM ensures the improvement of the quality management results of enterprises in industry 4.0, explaining the change in research and development outputs by 37.90%, ICT PCT patent applications (per 100 billion GDP) – by 22.77%,

impact of ICTs on business models – by 10.61%, high-technology trade (% total trade) – by 18.83%, quality of research institutions – by 21.54%, firm-level technology absorption – by 30.61%, as well as availability of latest technologies – by 30.61%.

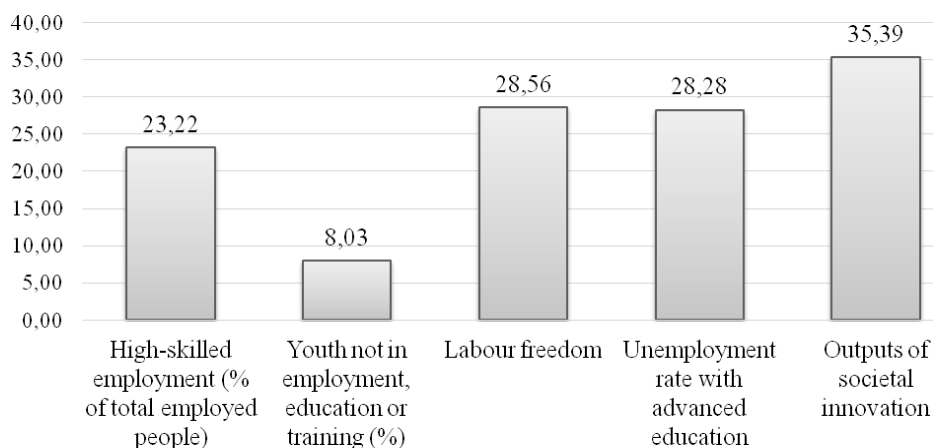


Figure 3. Contribution of responsible HRM practices to improving the effectiveness of quality management of enterprises in industry 4.0, %

Source: calculated and constructed by the authors.

According to Figure 3, responsible HRM practices make the following contribution to improving the effectiveness of quality management of enterprises in industry 4.0: the contribution of high-skilled employment (% of total employed people) is 23.22%, youth not in employment, education or training: 8.03%, labor freedom: 28.56%, unemployment rate with advanced education: 28.28%, and outputs of societal innovation: 35.39%. Thus, a significant contribution of responsible HRM practices to improving the quality management results of industry 4.0 enterprises has been identified, which formed the evidence base of the hypothesis H.

4.3. Improved quality management model of enterprises in industry 4.0 based on responsible HRM

To solve the third task of this study, related to determining the prospects for the improvement of quality management of enterprises in industry 4.0 on the basis of responsible HRM using the results of correlation analysis, a new model of this management has been developed (Fig. 4).

The innovation process in the context of its main stages

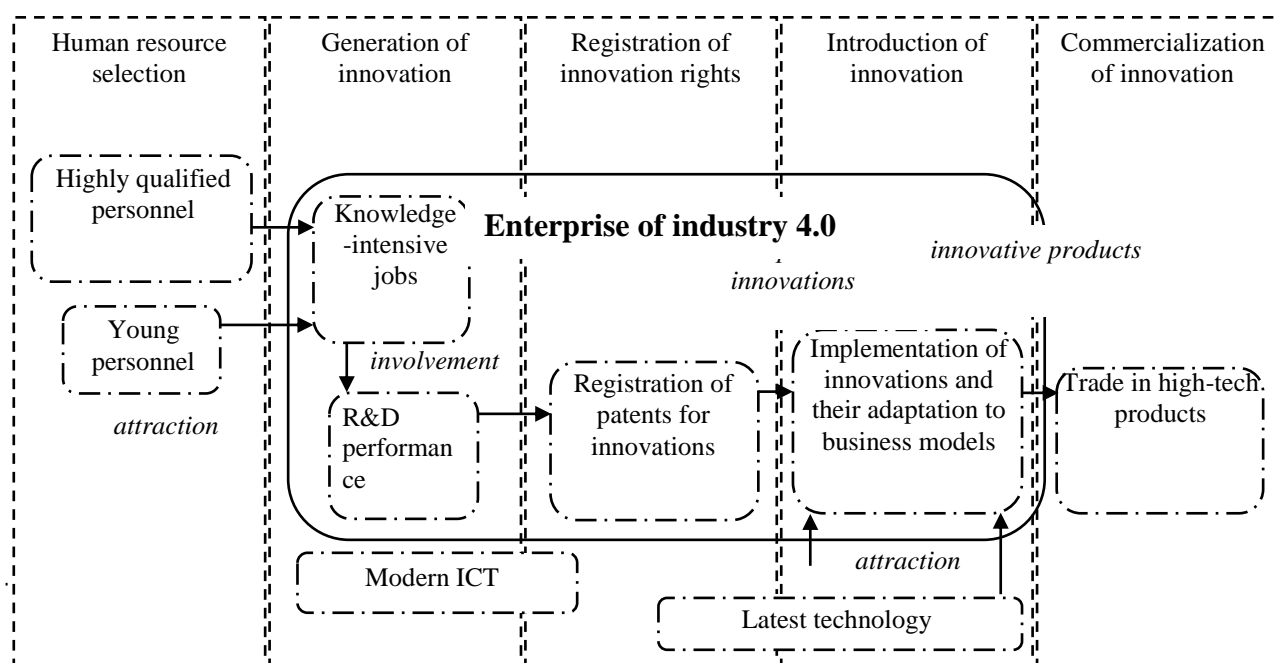


Figure 4. Improved model of quality management of enterprises in industry 4.0 based on responsible HRM

Source: developed by the authors.

As shown in Figure 4, the improved model provides advantages at all stages of the innovation process, systematically increasing the product quality of enterprises in industry 4.0 on the basis of responsible HRM. At the stage of selecting human resources, the model involves attracting highly qualified and young personnel to the enterprise of industry 4.0. At the stage of innovation generation, knowledge-intensive jobs are created for them, and the attracted personnel are involved in the R&D performance.

At the stage of registration of innovation rights, the created intellectual property objects are patented. At the stage of innovation implementation, the company's own innovations, as well as modern ICT and the latest technologies attracted externally, are mastered and adapted to the business models of industry 4.0. This

makes it possible to produce innovative products. At the stage of commercialization of innovation, high-tech products are traded.

5. DISCUSSION

The contribution of the article to the literature consists in the development of the provisions of the Theory of HR-related quality management in entrepreneurship through clarifying the consequences of responsible HRM for the quality of enterprises in industry 4.0 in Russia. To optimize these consequences, a new model based on responsible HRM is proposed as an alternative to the existing model based on personnel substitution. The models are compared in Table 4.

Table 4. Comparison of alternative HR-models of quality management of enterprises in industry 4.0

| Comparison criteria | Model based on personnel substitution | | Model of responsible HRM | |
|---|--|---|--|-------------------------|
| | The essence of the model | References | The essence of the model | Quantitative parameters |
| The importance of human resources for quality management of enterprises in industry 4.0 | Low: the product quality of enterprises in industry 4.0 is determined by technological resources | Degtyarova et al. (2016), Denisov et al. (2018), Karanina et al. (2022) | High: human resources contribute to: | Correlation |
| | | | – Improvement of research and development results | 37,90% |
| | | | – Increase in the number of patent applications in the field of ICT; | 22,77% |
| | | | – Extension of the influence of ICT on business models | 10,61% |
| | | | – Development of trade in both high technologies and high-tech products; | 18,83% |
| | | | – Improvement of the quality of research institutes; | 21,54% |
| | | | – Technological learning at the business level; | 30,61% |
| | | | – Attraction and enhancement of the activity and success of the introduction of the latest (advanced) technologies | 30,61% |
| The approach to HR-related quality management of enterprises in industry 4.0 | Automation: the release and transfer of personnel to the maintenance of automation equipment | Pankina (2015), Sozinova and Saveleva (2022) | Implementation of responsible HRM practices: | Correlation |
| | | | – Creation of knowledge-intensive jobs; | 23,22% |
| | | | – Provision of employment opportunities for young people as the most flexible, talented and creative personnel; | 8,03% |
| | | | – Guarantee of full protection of workers' labor rights and freedom of work; | 28,56% |
| | | | – Provision of employment opportunities for highly qualified personnel (with advanced education); | 28,28% |
| | | | – Introduction of social innovations to improve employment conditions for the benefit of workers. | 35,39% |

Source: developed by the authors.

As demonstrated in Table 4, unlike authors such as Degtyarova et al. (2016), Denisov et al. (2018), Karanina et al. (2022), the importance of human resources for quality management of enterprises in industry 4.0 is high. HRM defines a whole range of product quality management results for enterprises in industry 4.0:

- Improvement of research and development results (to support the position of Saihi et al., 2023);
- Increase in the number of patent applications in the field of ICT (to confirm the position of Dohale et al., 2023);

- Extension of the influence of ICT on business models (to support the position of Singh et al., 2022);
- Development of trade in both high technologies and high-tech products (to confirm the position of Moraes et al., 2023);
- Improvement of the quality of research institutes (to support the position of Alam and Dhamija, 2022);
- Technological learning at the business level (to confirm the position of Jain and Jain, 2022);
- Attraction and enhancement of the activity and success of the introduction of the latest (advanced) technologies (to support the position of Flores et al., 2020; Souza et al., 2022).

In contrast to the positions of such researchers as Pankina (2015), Sozinova and Saveleva (2022), the approach to HR-related quality management of enterprises in industry 4.0 should not involve automation, but the implementation of responsible HRM practices, including:

- Creation of knowledge-intensive jobs (to confirm the position of Yousaf and Palazzo, 2023);
- Provision of employment opportunities for young people as the most flexible, talented and creative personnel (to support the position of Federici et al., 2023);
- Guarantee of full protection of workers' labor rights and freedom of work (to confirm the position of Mohanan and Rajarathinam, 2023);
- Provision of employment opportunities for highly qualified personnel (with advanced education) (to support the position of Choudhary and Kunte, 2023);
- Introduction of social innovations to improve employment conditions for the benefit of workers (to confirm the position of Kersten et al., 2023; Shaji et al., 2023).

Thus, the article has strengthened the evidence base presented by Dhaigude et al. (2023), Ting et al. (2023) and has confirmed the hypothesis that the implementation of responsible HRM practices contributes to increasing the target results of quality management of enterprises in industry 4.0 in Russia: by 24.70%.

6. CONCLUSION

The main conclusion based on the results of the study is that responsible HRM occupies a central place in the quality management system of enterprises in industry 4.0 in Russia. In particular, the following results have been obtained. Firstly, the study of Russia's experience for 2021–2023 based on the statistics of the stock indices of the Moscow Exchange revealed that the

development of enterprises in industry 4.0 is due to corporate social responsibility (proved by the example of telecommunications). The short-term (until the end of 2023) perspective of the development of industry 4.0 enterprises based on corporate social responsibility in Russia is associated with an increase in the level of development of enterprises in industry 4.0 by 8.36 times, and the long-term perspective (in the "Decade of Action": until 2030) - with an increase in this level by 12.84 times.

Secondly, on the basis of statistics for 2018–2021, a significant contribution of responsible HRM to improving the effectiveness of quality management of enterprises in industry 4.0 in Russia has been substantiated. The article has proved that the final contribution of responsible HRM to achieving the results of quality management of enterprises of industry 4.0 is quite high and amounts to 24.70%. The authors have selected promising practices of responsible HRM that make a significant contribution to improving the effectiveness of quality management of enterprises in industry 4.0: high-skilled employment (contribution estimated at 23.22%), youth not in employment, education or training (8.03%), labor freedom (28.56%), unemployment rate with advanced education (28.28%), as well as outputs of societal innovation (35.39%).

The article has substantiated the advantages of using responsible HRM in the implementation of quality management of enterprises in industry 4.0, including: an increase in research and development outputs (due to the combination of factors responsible HRM by 37.90%), a rise in ICT PCT patent applications (22.77%), an increase in the impact of ICTs on business models (10.61%), a rise in high-technology trade by (18.83%), an increase in the quality of research institutions (21.54%), a rise in firm-level technology absorption (30.61%), as well as an increase in availability of latest technologies (30.61%)

Thirdly, the article has presented an improved model of quality management of enterprises in industry 4.0 based on responsible HRM, which makes it possible to fully unlock the potential of quality improvement with the help of HRM. The theoretical significance of the results obtained in the course of the study is due to the fact that they have clarified and systematized the consequences of responsible HRM for the quality of enterprises in industry 4.0, as well as have revealed the unique experience of Russia. The improved model of quality management at enterprises of industry 4.0 has identified the key management practices and advantages of responsible HRM at each stage of the innovation process. This makes it possible to regulate the processes of HR-related quality management in industry 4.0.

The practical significance of the authors' conclusions and developments is that they contribute to the disclosure of the potential for improving the product quality of industry 4.0 in Russia in the "Decade of

Action". The managerial significance of the recommendations proposed in the article is due to the fact that they fully take into account the specifics of the Russian industry 4.0 in HR-related quality management. The social significance of the research results is related to the fact that they provide a deeper integration of SDG9 into the practice of quality management in industry 4.0.

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7. ACKNOWLEDGEMENTS

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Appendix

Table 3. Results of quality management of enterprises in industry 4.0 in 2018-2021 and correlation analysis of the relationship with the practices of responsible HRM

| Indicators | | Research and Development Outputs | ICT PCT patent applications (per 100 billion GDP) | Impact of ICTs on business models | High-technology trade (% total trade) | Quality of research institutions | Firm-Level technology absorption | Availability of latest technologies | Arithmetic average of positive correlation coefficients, % | The proportion of positive correlation coefficients | Final contribution, % |
|--|--|----------------------------------|---|-----------------------------------|---------------------------------------|----------------------------------|----------------------------------|-------------------------------------|--|---|---|
| Values, points 1-100 | 2018 | 26.60 | 13.50 | 50.40 | 10.60 | 56.60 | 56.20 | 56.90 | - | - | - |
| | 2019 | 26.10 | 13.50 | 45.30 | 79.70 | 57.20 | 52.20 | 45.70 | - | - | - |
| | 2020 | 27.10 | 26.50 | 45.30 | 22.70 | 57.20 | 52.20 | 45.70 | - | - | - |
| | 2021 | 27.10 | 46.60 | 45.30 | 47.90 | 57.20 | 52.20 | 45.70 | - | - | - |
| Correlation with responsible HRM practices, % | High-skilled employment | -59.96 | -17.12 | -68.37 | 94.16 | 68.37 | -68.37 | -68.37 | 81.27 | 0.29 | 23.22 |
| | Youth not in employment, education or training | 16.91 | -21.53 | -39.33 | -12.35 | 39.33 | -39.327 | -39.33 | 28.12 | 0.29 | 8.03 |
| | Labour freedom | -19.50 | -50.61 | 99.98 | -63.15 | -99.98 | 99.98 | 99.98 | 99.98 | 0.29 | 28.56 |
| | Unemployment rate with advanced education | 93.31 | 53.25 | 17.13 | -82.08 | -17.13 | 17.13 | 17.13 | 39.59 | 0.71 | 28.28 |
| | Outputs of societal innovation | 79.30 | 60.60 | 35.93 | -71.25 | -35.93 | 35.93 | 35.93 | 49.54 | 0.71 | 35.39 |
| Assessment of the relationship with the practices of responsible HRM | Arithmetic average of positive correlation coefficients, % | 63.17 | 56.93 | 26.53 | 94.16 | 53.85 | 51.01 | 51.01 | - | - | - |
| | The proportion of positive correlation coefficients | 0.60 | 0.40 | 0.40 | 0.20 | 0.40 | 0.60 | 0.60 | - | - | - |
| | Final contribution, % | 37.90 | 22.77 | 10.61 | 18.83 | 21.54 | 30.61 | 30.61 | - | - | 24.70 (I_{HRM4.0}) |

Source: compiled and calculated by the authors based on the materials of Knoema (2023).