Research article
DOI: https://doi.org/10.48554/SDEE.2021.2.2

INNOVATION AND RESOURCE POTENTIAL ON KEY PERFORMANCE INDICATORS OF WATER SUPPLY ENTERPRISES

Alina Furtatova[1]*, Natalia Victorova[1], Evgenii Konnikov[1]

[1] Peter the Great St. Petersburg Polytechnic University, Saint Petersburg, Russia,
alina_furtado@mail.ru, viktorova_ng@spbstu.ru, konnikov_ea@spbstu.ru
* Corresponding author: alina_furtado@mail.ru

Abstract

The article analyses the innovation and resource potential of an enterprise as the basis for its sustainable development. The factors of structure, assessment and impact of this potential on individual resulting performance indicators are considered. This study identified the natural links between innovation and resource potential and the indicators of profit, revenue, costs, volumes of water losses and consumption. Thus, the probable links between potential and the financial, environmental and social components that characterise the activities of an enterprise are elucidated. The study used expert assessments and regression analyses on data from the SUE 'Vodokanal of St. Petersburg'. The value of innovation and resource potential was determined by summing up the values of constituent elements (subpotentials): educational and personnel, research, information and technological, production and technical, socioenvironmental, financial and economic as well as organisational and managerial. For each subpotential, a system of indicators was developed. Calculations of indicators were done for data from 2010–2020. Indicators were ranked by degree of importance. After determining the value of the innovation and resource potential, six regression models were built, reflecting the impact of potential on key performance indicators of the water supply enterprise. The results of the study demonstrated profit, revenue and cost indicators' direct dependence on innovation and resource potential and the inverse dependence of water loss and consumption. Studying indicators characterising a particular subpotential and selecting resulting indicators for modelling and assessing the impact of innovation and resource potential remain problematic. The results show that subpotential improvement can be achieved by identifying indicators, such as personnel and technological support that depend on innovation and resource potential for major advancements. This can improve the effectiveness and efficiency of water supply enterprises, making this an important area of scientific inquiry.

Keywords: innovation and resource potential, subpotentials, water supply enterprise, sustainable development, regression analysis, regression model.

Citation: Furtatova, A., Victorova, N., Konnikov, E., 2021. Innovation and resource potential on key performance indicators of water supply enterprises. Sustainable Development and Engineering Economics 2, 2. https://doi.org/10.48554/SDEE.2021.2.2

Научная статья
УДК 338.45
DOI: https://doi.org/10.48554/SDEE.2021.2.2

ОЦЕНКА ВЛИЯНИЯ ИННОВАЦИОННО-РЕСУРСНОГО ПОТЕНЦИАЛА НА КЛЮЧЕВЫЕ ПОКАЗАТЕЛИ ДЕЯТЕЛЬНОСТИ ПРЕДПРИЯТИЙ ВОДОСНАБЖЕНИЯ

Алина Фуртатова[1]*, Наталья Викторова[1], Евгений Конников[1]

[1] Санкт-Петербургский политехнический университет Петра Великого, Санкт-Петербург, Россия, alina_furtado@mail.ru, viktorova_ng@spbstu.ru, konnikov_ea@spbstu.ru

* Автор, ответственный за переписку: ektereshko@mail.ru

Аннотация

Статья посвящена инновационно-ресурсному потенциалу предприятия как основе его устойчивого развития. В ней рассмотрены вопросы структуры, оценки и влияния потенциала на отдельные результирующие показатели деятельности применительно к предприятиям водоснабжения. Цель исследования состоит в выявлении закономерных связей между инновационно-ресурсным потенциалом и показателями прибыли, выручки, затрат, объемов потерь и потребления воды. Таким образом, в исследовании обозначены вероятные связи потенциала с финансовой, экологической и социальной компонентами, характеризующими деятельность предприятия. Исследование выполнено на материалах ГУП «Водоканал Санкт-Петербурга». В работе использованы метод экспертных оценок и регрессионный анализ. Значение инновационно-ресурсного потенциала определено путем суммирования величин его составных элементов (субпотенциалов): образовательно-кадрового, научно-исследовательского, информационно-технологического, производственно-технического, социально-экологического, финансово-экономического, организационно-управленческого. Для каждого субпотенциала разработана система показателей. Расчеты показателей произведены за период 2010–2020 гг. Показатели проранжированы по степени значимости. После определения значения инновационно-ресурсного потенциала построено шесть регрессионных моделей, отражающих влияние потенциала на ключевые показатели деятельности предприятия водоснабжения. Результаты исследования показали прямую зависимость от инновационно-ресурсного потенциала показателей прибыли, выручки и затрат, и обратную зависимость потерь и потребления воды. Дискуссионными остались вопросы выделения в исследовании показателей, характеризующих тот или иной субпотенциал, а также отбора результирующих показателей для моделирования и оценки влияния на них инновационно-ресурсного потенциала. В заключении исследования предложены направления совершенствования субпотенциалов. Интерес для будущих научных разработок представляет выявление зависимости инновационно-ресурсного потенциала и показателей, характеризующих кадровое и технологическое обеспечение деятельности предприятия водоснабжения.

Ключевые слова: инновационно-ресурсный потенциал, субпотенциалы, предприятие водоснабжения, устойчивое развитие, регрессионный анализ, модель.

Цитирование: Фуртатова, А., Викторова, Н., Конников, Е., 2021. Оценка влияния инновационно-ресурсного потенциала на ключевые показатели деятельности предприятий водоснабжения. Sustainable Development and Engineering Economics 2, 2.
https://doi.org/10.48554/SDEE.2021.2.2

1. Introduction

Given the conditions of limited water resources and environmental problems, the issue of the effectiveness of water supply enterprises is becoming more important. Some territories are characterised by a shortage of fresh water and other territories by its low quality. Even if these indicators are normal, problems of water loss arise. However, on a global scale, all these problems coexist, so special attention needs to be paid to the management of water resource potentials through the analysis of water consumption.

Water is the greatest natural resource involved in the human economy. In terms of annual use, it exceeds all key extracted resources. Water is a vital resource; it participates in the manufacturing of goods and services, the development of energy, industry and agriculture (Furtatova and Kamenik, 2018).

The United Nations world water development report 2020: water and climate change noted that over the past hundred years, global water use has increased sixfold, and every year this indicator has increased by 1% due to a number of factors, including demographic growth, economic development and changing patterns of water consumption (UNESCO, 2020).

To date, according to *The Sustainable Development Goals Report 2020*, 2.2 billion people around the world do not have safe and organised access to drinking water, which is 28% of the world's population (DESA, 2020). This situation has developed not only for geographical reasons, but also due to population growth, urbanisation, economic development, climate change and the high level of pressure on water resources, which arose as a result of previous ineffective management.

Globally, the load on water resources is 17%, indicating a generally safe level of freshwater use today; however, this figure varies significantly between regions (DESA, 2020).

The situation of water losses as a result of its transportation is also problematic. The average value of this indicator among Western European enterprises is 10.8 m^3/km per day, and in Russia, it is 29.4 m^3/km per day (EBC, 2018).

The global international studies and statistics presented above justify the need to revise the management model of water supply enterprises, including the management of their potential.

2. Literature Review

Many scientists around the world are devoted to studying potential and its characteristics, properties and methods of determination. From the socioeconomic aspect, the assessment of potential sets itself the goal of ensuring the sustainable development of a country, industry or enterprise. Depending on the territorial, economic, political, cultural and other features of economic objects, researchers analyse the potential by dividing it into its constituent elements or considering its integrated essence. A variety of tools are used for this.

Canci (2021) assessed the innovative potential of the United States over the past decades. It proved the association between innovation and the state of the national economy. As a result of the growth of the innovative potential of the United States, labour productivity has improved, and the influence of the market economy and capitalism has increased. The increase in the use of scientific technologies and developments in various fields has ensured the sustainable innovative development of the country's economy (Rudskaia and Rodionov, 2018).

Fallah-Alipour et al. (2018) studied potential in the agricultural industry by assessing potential based on a system of environmental, social, economic and other indicators. The tools for this system's implementation were sustainability maps, diagrams and a barometer of sustainability. The results allowed the formulation of recommendations for effective land use, ensuring sustainable development of the country.

Scientists have also used various approaches to study potential. Nehrebecka (2018) assessed the financial potential of an enterprise based on modelling using regression logarithmic equations. The effective use of financial potential was compared here with the indicator of the probability as default. The study concluded that the lowest risk of bankruptcy was observed in the pharmaceutical industry, and the highest risk of bankruptcy was in the mining sector.

Stewart et al. (2018) used a model to assess the life cycle of an enterprise as determined by its sustainable development based on data from more than 45 000 corporate reports. The model included the main tasks, opportunities and recommendations for expanding the potential of the enterprise.

A non-trivial approach to managing sustainable innovative development of an enterprise proposed by Vasilieva et al. (2020) assessed innovative potential using the specialised software CASI-F created by Popper et al. (2017). They conducted a meta-analysis of roadmaps compiled through CASI-F. The applied methodology allowed the authors to identify strengths and weaknesses, as well as opportunities and threats in assessing the sustainable innovative development of the enterprise.

Abouhamad and Abu-Hamd (2020) assessed the potential of one of the innovative technologies in the construction industry using the Athena Impact Estimator program. Furthermore, Graciano et al. (2018) assessed the environmental and economic potential of one of the innovative biotechnologies.

Martins et al. (2018) constructed a model for assessing the potential of electric power generation companies in Portugal in the context of their life cycle. The results of the simulations allowed them to develop avenues for the effective management of such enterprises, including the reduction of greenhouse gas emissions as a result of the introduction of 'green' technologies. In a continuation of the issue of assessing the potential of a country's electric power industry, Hulio et al. (2017) substantiated the need for the calculation and economic assessment of the potential of wind energy. In the paper, the authors proved (through the application of mathematical statistics and the coefficient of determination of the model) the expediency of using power plants operating on wind energy.

Along with assessing the potential of the country, industry, enterprise and technology, studies have assessed other types of potential. For example, the potential of waste (Iacovidou et al., 2017) and the potential of products (plastic parts) used in automotive production (Dobransky, 2019) have also been assessed.

However, the works of greatest interest in this study are the works that assessed water potential. Specifically, Moro et al. (2019) compared the national innovation potential of European countries and China in the water sector. They concluded that this potential is higher in European countries and that the development of primarily environmental innovations determines the level of national water innovation potential.

Researchers from South Korea (Park and Kim, 2021) estimated the predicted potential of using groundwater sources in the country using big data. The authors emphasised the need to create groundwater potential maps for the effective management of groundwater sources' potential.

Bertuzzi and Ghisi (2021) assessed the potential of the use of rainwater in the technological process in the enterprises of Brazil. The authors simulated the enterprise's future demand for water for technological purposes and revealed that it is twice the current consumption. Thus, technology for using rainwater was proposed, including its additional purification before use, which ensures the quality of the resource, and the economic feasibility of introducing this technology was also estimated.

Regardless of the object (country, technology, enterprise, industry, products, etc.) considered by researchers, the assessment of each potential is aimed at ensuring the sustainable development of the relevant object and emphasises the importance of considering the environmental factor, the primary factor of production (natural resource capital). However, the assessment of innovation and resource potential of water supply enterprises and its influence on the resulting performance indicators have been insufficiently covered in the literature. This problem is therefore the focus of this article.

3. Materials and Methods

This study develops a methodology for assessing water supply enterprises and their activities' (financial, environmental and social) dependence on innovation and resource potential. The objectives of the study (in relation to the specifics of the type of activity under consideration) include 1) the determination of the innovation and resource potential of the enterprise and its constituent elements (subpotentials); 2) the development of a system of indicators for assessing each type of subpotential; 3) the assessment of innovation and resource potential and 4) the construction of models reflecting the influence of innovation and resource potential on the results of the financial, environmental and social activities of the enterprise.

Research hypotheses:

1) Innovation and resource potential affect the income and profit of a water supply enterprise as a business entity and is not significant in cost processes.

2) Since one of the main goals of the water supply enterprise is to provide the population with water, it can be assumed that of all three components selected for the study that characterise the results of the enterprise's activities, innovation and resource potential has the greatest impact on the social component.

For the purposes of this study, innovation and resource potential is understood as a complex integral indicator reflecting the qualitative characteristics of the current and future capabilities of an enterprise. The object of the study is the water supply enterprise SUE 'Vodokanal of St. Petersburg'. The empirical base for the study was formed over 11 years during the period from 2010 to 2020 on the basis of data from the annual reports of SUE 'Vodokanal of St. Petersburg' and its divisions.

The research methodology is as follows.

1. The value of the innovation and resource potential of the water supply enterprise is calculated.

1.1. Innovation and resource potential is divided into its constituent elements (subpotentials).

1.2. A system of indicators is developed for each subpotential.

1.3. The significance of each indicator is determined using the ranking method and expert assessments.

1.4. The size of each subpotential (integral value) is calculated.

1.5. The integral value of innovation and resource potential is determined.

2. The dependence of a water supply enterprise on its innovation and resource potential is assessed.

2.1. The resulting indicators for constructing models are selected, and models are formed.

2.2. The reliability and significance of the constructed models are checked using the coefficient of determination, approximation error, P-level and regression coefficient (Smith, 2015; Georgiev et al., 2018; Furtatova and Kamenik, 2019).

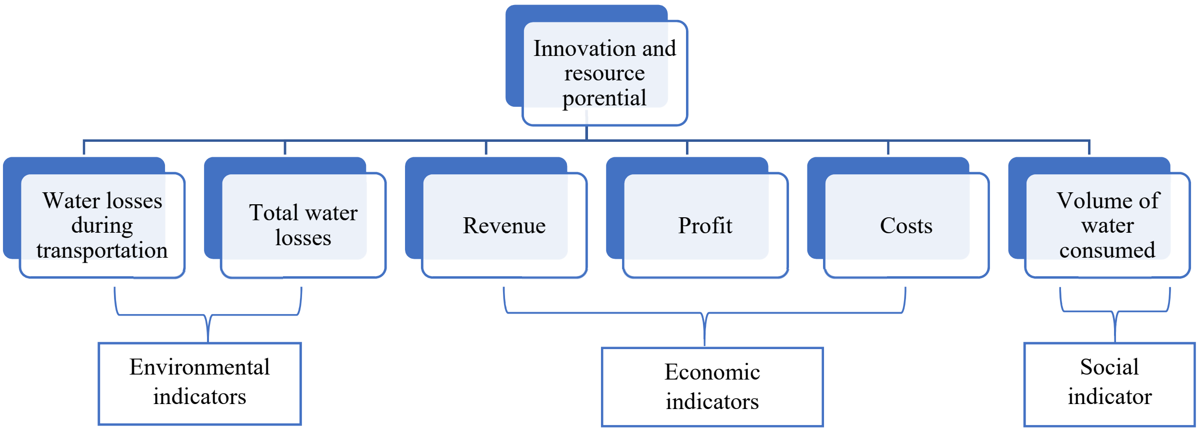

Figure 1. Conceptual model for constructing regression models.

The methodology for identifying the dependencies of the resulting performance indicators of the water supply enterprise on innovation and resource potential is based on regression analysis. Below is a conceptual diagram of the relationships between the indicators used to build regression models in the study (Fig. 1).

As the resulting indicators for modelling, indicators characterising the sustainability of the development of the water supply enterprise were chosen as follows: 1) group of environmental indicators (water loss during transportation and total water loss); 2) group of economic indicators (profit, costs and revenue) and 3) social indicator, provision of consumers with drinking water (volume of water consumed; Furtatova and Kamenik, 2019). The data are shown in Table 1.

Table 1. Initial data for building regression models

Year	Water loss during transportation (thousand m^3)	Total water loss (thousand m^3)	Revenue (thousand rubles)	Profit (thousand rubles)	Profit (thousand rubles)	Volume of water consumed (thousand m^3)
2010	104806.24	276205.14	9425693.50	2525945.50	6899748.00	623240.16
2011	98577.91	242951.61	9583548.70	2658912.20	6924636.50	603295.59
2012	91265.20	230683.60	9486346.10	2521985.70	6964360.40	587032.10
2013	89090.30	243298.30	9632589.20	2507219.50	7125369.70	570134.40
2014	81005.10	213103.80	9789586.50	1987436.90	7802149.60	544120.90
2015	77492.00	211357.90	10899258.40	2149134.60	8750123.80	519498.20
2016	71645.80	209433.50	11250988.20	1351862.90	9899125.30	512487.30
2017	62443.44	193226.64	12937890.20	2739125.60	10198764.60	505476.06
2018	57572.05	182273.65	14279390.80	4106666.60	10172724.20	504936.05
2019	53243.48	174187.48	15112625.90	5247537.70	9865088.20	504305.72
2020	51859.17	154340.77	15963124.50	6199561.90	9763562.60	504142.13

All calculations of regression analysis were done in MS Excel.

4. Results

Based on previously conducted research by domestic and foreign researchers, in terms of the types of potential inherent in an organisation in relation to water supply enterprises, the following subpotentials must be considered: educational and personnel, research, information and technological, production and technical, socioenvironmental, financial and economic, organisational and managerial subpotentials (Furtatova and Viktorova, 2020).

The authors developed a system of indicators characterising each type of subpotential. In general, 62 indicators were included in the calculation process (Table 2); all indicators were relative, calculated as the ratio of the specific indicator of the subpotential under consideration of the total indicator for the subpotential under study.

Table 2. List of indicators for assessing subpotentials of innovation and resource potential of a water supply enterprise

Subpotential name	Relative indicators reflecting the specific element of the subpotential
Educational and personnel	1. Staff education / 2. Staff professional literacy / 3. Professional growth of employees / 4. Interest of graduates in the enterprise as an employer / 5. Rejuvenation of the team / 6. Employment of graduates / 7. Activity of employees / 8. Involvement of employees in the development of the enterprise / 9. Success of employees / 10. Merit of employees / 11. Merit of employees within the enterprise / 12. Merit of employees at the city level.
Research	1. Intellectual property of the water supply enterprise / 2. Intensity of use of intellectual property of the enterprise / 3. Intensity of use of the acquired intellectual property of the enterprise / 4. Introduction of innovative technologies by third-party organisations / 5. Involvement of research organisations in conferences held at the enterprise / 6. Involvement of commercial organisations in the conferences held at the enterprise.
Information and technological	1. Provision of software products to production departments of the water supply enterprise / 2. Provision of software products to non-production departments of the water supply enterprise / 3. Continuity of the software functioning in the production departments of the water supply enterprise / 4. Continuity of the software functioning in the non-production departments of the water supply enterprise / 5. Automation of technological operations within the technological process of production departments of the water supply enterprise / 6. Automation of technological processes in the production departments of the water supply enterprise / 7. Automation of operations within the process of non-production departments of the water supply enterprise / 8. Automation of processes in the non-production departments of the water supply enterprise.
Production and technical	1. Use of key production equipment / 2. Wear of key production equipment / 3. Use of auxiliary equipment / 4. Wear of auxiliary equipment / 5. Renewal of key production equipment / 6. Renewal of auxiliary equipment / 7. Intensity of modernisation of objects of the water supply enterprise / 8. Intensity of reconstruction of objects at the water supply enterprise / 9. Intensity of new construction of objects at the water supply enterprise / 10. Intensity of repair of objects at the water supply enterprise / 11. Use of resource-saving technologies by the water supply enterprise / 12. Use of resource-intensive technologies by the water supply enterprise

Table 2. (continued)

Subpotential name	Relative indicators reflecting the specific element of the subpotential
Socioenvironmental	1. Supply of water from the water source / 2. Water consumption for servicing the water supply grids / 3. Water consumption in the production process / 4. Taxes for the negative environmental impact / 5. Economy of water resources by the employees of the water supply enterprise / 6. Satisfaction of employees with the working conditions of the water supply enterprise / 7. Satisfaction of the employees with the quality of water supply services of the enterprise / 8. Awareness of the population of the activities of the water supply company
Financial and economic	1. Financial independence of the water supply enterprise / 2. Share of borrowed funds in the capital of the water supply enterprise /3. Share of budget funds in the capital of the water supply enterprise / 4. Accounts receivable of the water supply enterprise / 5. Accounts payable of the water supply enterprise / 6. Financing activities of the water supply enterprise with its own funds / 7. Budget financing activities of the water supply enterprise / 8. Credit financing activities of the water supply enterprise / 9. Investment in the implementation of activities of the water supply enterprise / 10. Implementation of public–private partnership mechanisms at the water supply enterprise.
Organisational and managerial	1. Subordination of personnel at the water supply enterprise / 2. Share of workers in the personnel of the water supply enterprise / 3. Share of specialists in the personnel of the water supply enterprise / 4. Share of managers in the personnel of the water supply enterprise / 5. Career growth of the employees of the water supply enterprise / 6. Additional education of managers at the water supply enterprise.

Furthermore, based on expert assessments, each indicator was assigned a weight coefficient. To this end, the company has selected groups of experts responsible for the formation of a specific type of subpotential. Experts ranked the indicators by their importance, which made it possible to calculate the weight coefficient for each of the indicators. In Table 3, using the organisational and managerial subpotential as an example, such a calculation is provided.

Table 3. Assignment of weight coefficients to indicators of organisational and managerial subpotential

Expert	Indicators of evaluation of organisational and managerial subpotential					
	Subordination of personnel at the water supply enterprise	Share of workers in the personnel of the water supply enterprise	Share of specialists in the personnel of the water supply enterprise	Management structure at the water supply enterprise	Career growth of employees of the water supply enterprise	Additional education of managers at the water supply enterprise
Director of the water supply enterprise	4	2	1	6	5	3
Deputy director for general affairs	5	1	2	5	3	6
Senior management specialist	6	5	4	3	2	1
Senior specialist for coordination of work of the manager	3	2	1	6	4	5

Table 3. (continued)

Expert	Indicators of evaluation of organisational and managerial subpotential					
	Subordination of personnel at the water supply enterprise	Share of workers in the personnel of the water supply enterprise	Share of specialists in the personnel of the water supply enterprise	Management structure at the water supply enterprise	Career growth of employees of the water supply enterprise	Additional education of managers at the water supply enterprise
Senior referent-coordinator	2	3	4	5	6	1
Chief operations specialist	6	2	5	4	1	3
Head of systems analysis of services	4	6	5	3	2	1
Leading specialist of the office management service	1	3	2	6	4	5
Deputy director for human resources policy and corporate communications	4	1	2	6	5	3
Leading specialist of HR administration department	1	3	2	4	5	6
Sum	36	28	28	48	37	34
Weights	0.171	0.133	0.133	0.227	0.175	0.161

Then, the integral values for each subpotential were calculated by multiplying the weight coefficients by the corresponding values of the subpotential indicators (Table 4).

Table 4. Estimated values of subpotentials and innovation and resource potential of the water supply enterprise

Subpotential	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Educational and personnel	0.268	0.294	0.293	0.298	0.303	0.309	0.302	0.300	0.296	0.289	0.291
Research	0.312	0.316	0.323	0.320	0.319	0.316	0.311	0.314	0.315	0.319	0.321
Information and technological	0.472	0.485	0.517	0.529	0.539	0.532	0.543	0.556	0.563	0.569	0.575
Production and technical	0.365	0.367	0.389	0.383	0.379	0.386	0.385	0.386	0.379	0.378	0.380
Socioenvironmental	0.611	0.612	0.617	0.613	0.630	0.629	0.623	0.640	0.644	0.642	0.651
Financial and economic	0.284	0.284	0.288	0.285	0.275	0.276	0.259	0.279	0.299	0.311	0.328
Organisational and managerial	0.299	0.292	0.306	0.328	0.329	0.322	0.336	0.339	0.337	0.337	0.331
Innovation and resource potential	2.610	2.651	2.733	2.756	2.775	2.769	2.761	2.814	2.834	2.844	2.876

Further, six regression models were constructed to describe the relationship between the innovation and resource potential with a specific indicator reflecting the result of the activities of the water supply enterprise. X is the value of the innovation and resource potential, and $Y_1 \ldots Y_n$ (where $n=6$) is the value of the resulting indicator.

Model 1. The influence of innovation and resource potential on water loss during transportation (Fig. 2).

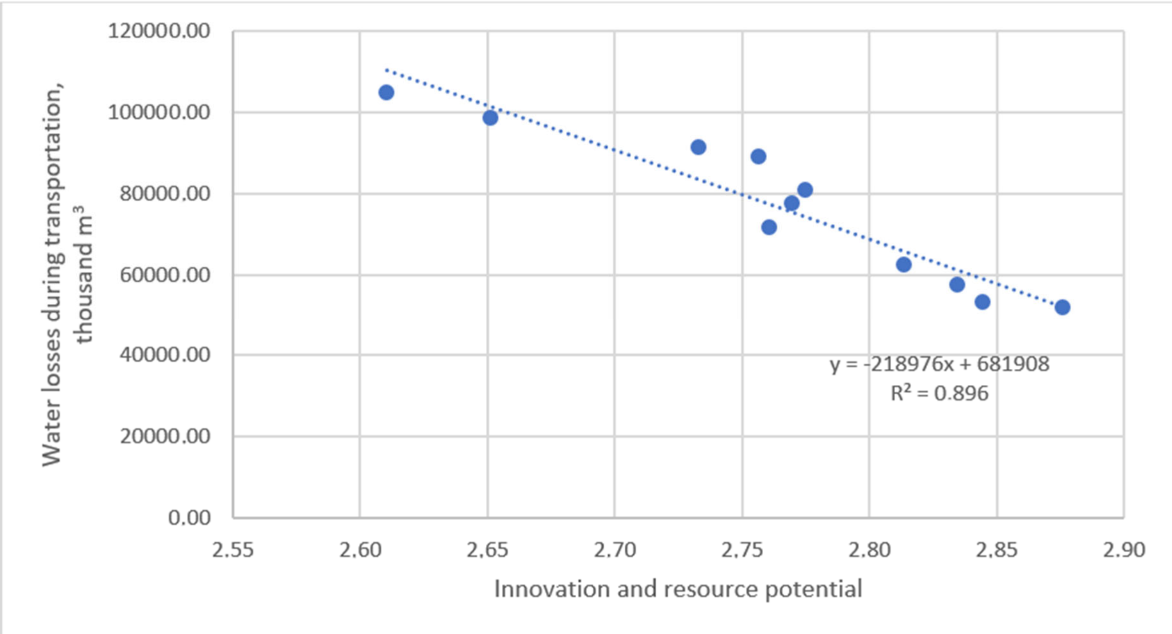

Figure 2. Relationship between indicators of innovation and resource potential and water loss during transportation

The highest coefficient of determination was obtained by selecting a linear function (89.6%). Thus, 89.6% of changes in the value of the indicator 'water loss during transportation' can be described by the value of innovation and resource potential.

The practical significance of this approximation error indicator is interpreted as follows: on average, the constructed model when predicting the indicator 'water loss during transportation', calculated on the basis of the value of innovation and resource potential, is erroneous by 8.23%.

The value of the F-criterion is equal to the p-value, since these are equations of pair regressions, demonstrating the degree of reliability of the model and proving that the value of the innovation and resource potential affects the indicator under consideration.

Model 2. The influence of innovation and resource potential on the total water loss at the water supply enterprise (Fig. 3).

This model is reliable, based on the P-level and the approximation error, the value of which was 5.61%.

The coefficient of determination was almost 90%; that is, the compiled model explained 90% of the described variance.

The vector of influence in this case took a negative value. Thus, with an increase in innovation and resource potential, total water loss would decrease. This could be achieved through repairs, reconstruction and new construction of water supply facilities.

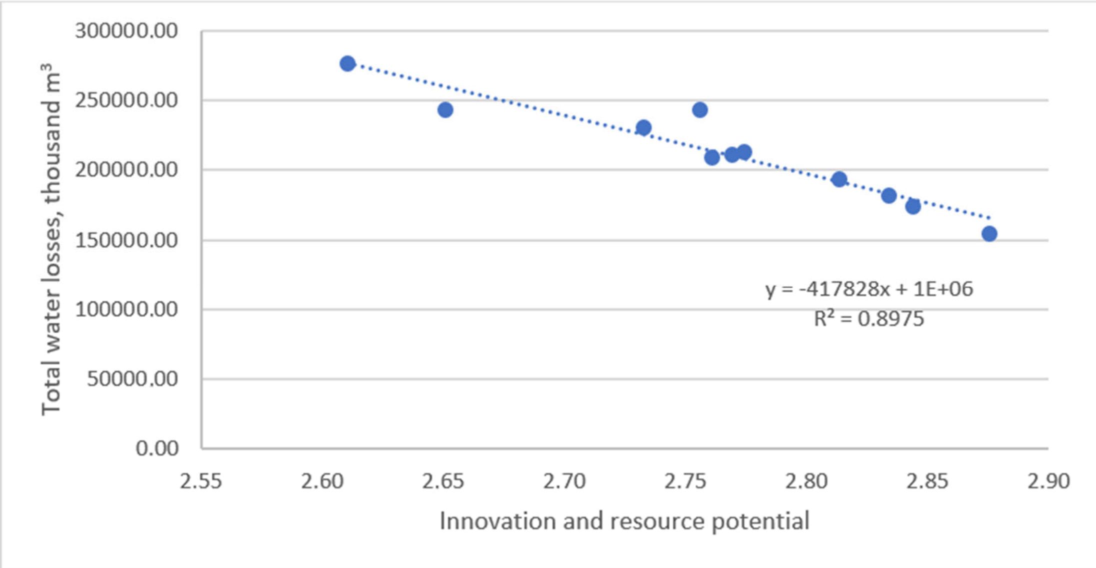

Figure 3. Relationship between indicators of innovation and resource potential and total water loss

Model 3. The influence of innovation and resource potential on revenue from the sale of services (Fig. 4).

The P-level = 99% and standard error =12.45% for the model, meaning that 69% of the obtained variance of the studied indicator can be explained by a change in the innovation and resource potential.

In this model, the vector of influence took a positive value: an increase in the innovation and resource potential would increase revenue. However, with such an approximation error, this effect would be achieved gradually.

Model 4. The influence of innovation and resource potential on profit (Fig. 5).

When constructing a linear equation of the 'Profit' indicator, the coefficient of determination was 0.374; thus, the innovation and resource potential described 37.4% of the changes in the resulting indicator under consideration, which is insufficient for the analysis of the model. In addition,

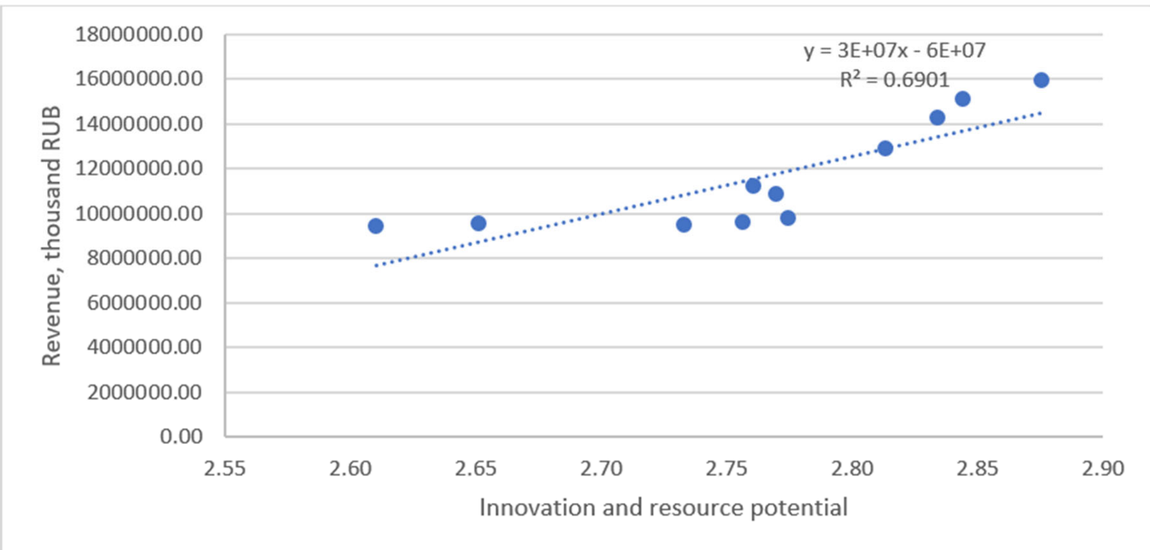

Figure 4. Relationship between indicators of innovation and resource potential and revenue

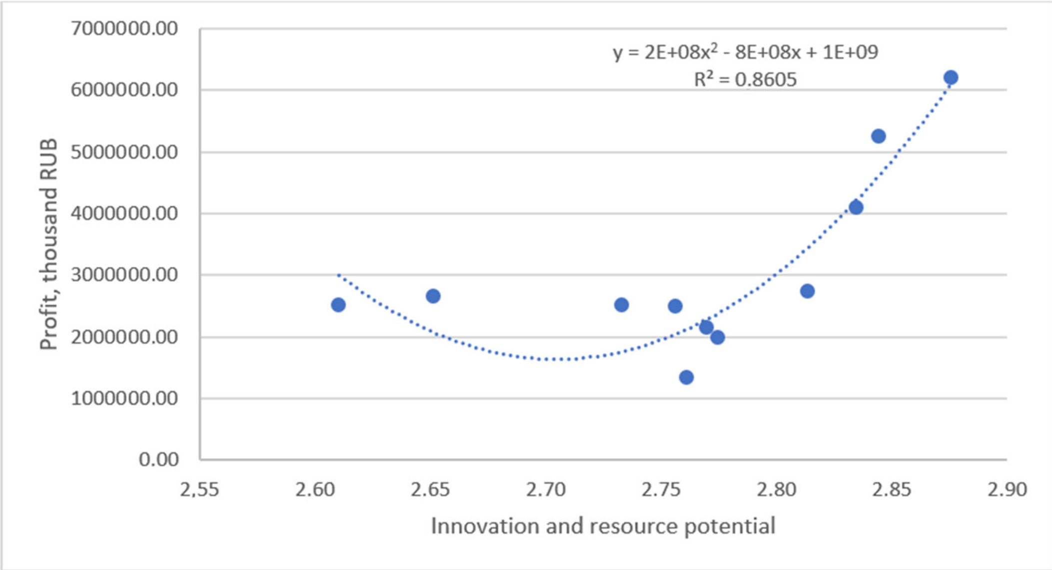

Figure 5. Relationship between indicators of innovation and resource potential and profit

the value of the F-criterion was 0.04561, and the value of the approximation error was 39.82%, which shows the low degree of reliability and practical quality of this model.

To describe the influence of innovation and resource potential on profit, the equation of the polynomial of the second degree is chosen (Song and Li, 2021). In this model, the coefficient of determination was 86%, but the standard error was almost 20%, which indicates that the model is unreliable. However, the importance of the F-criterion indicates that the value of innovation and resource potential has a significant impact on the profit of a water supply enterprise.

It is worth noting here that the value of the standard error was 19.94%, so we can conclude that with an increase in innovation and resource potential, the return on profit would be observed a little later.

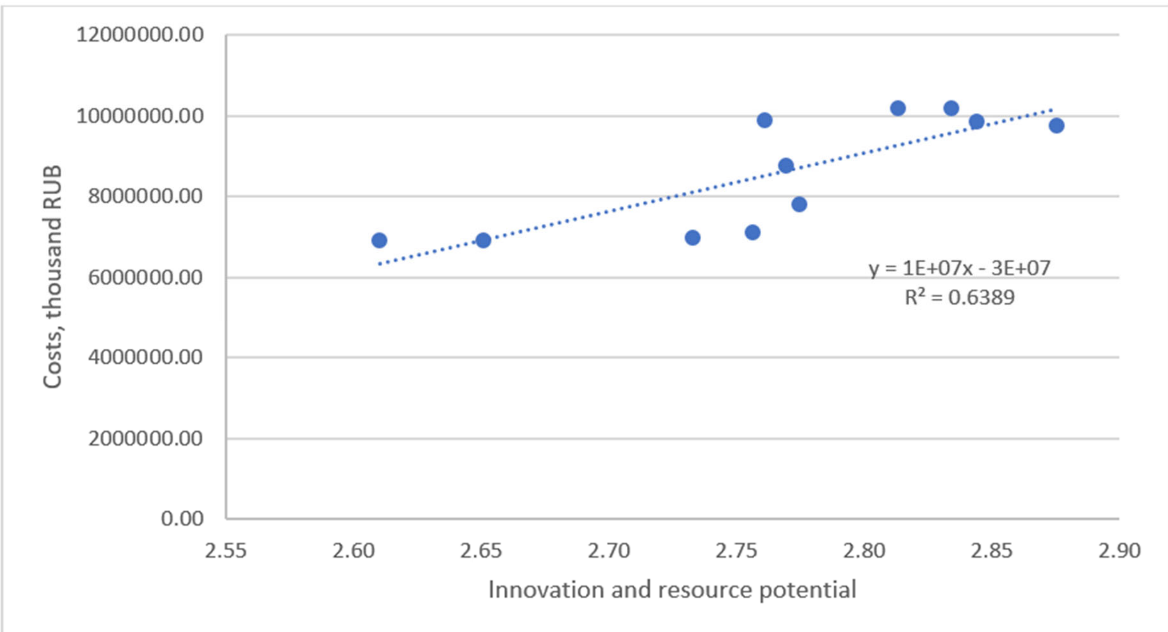

Figure 6. Relationship between indicators of innovation and resource potential and costs

According to the obtained model, increasing the innovation and resource potential from 2.61 to 2.73, the profit value decreased markedly. In this period, the basis for further increment of the economic result (construction of new capacities, reconstruction of existing facilities, etc.) is formed. At the end of this period, the importance of innovation and resource potential increased, thereby indicating an increase in the economic effect at the enterprise (profit growth).

Thus, the value of innovation and resource potential equal to 2.73 is the value of this indicator, up to which the increment of innovation and resource potential is vital for the functioning of the water supply enterprise, and after the transition of the value to 2.73, an increase in the profit of the enterprise will be noticeable.

Model 5. The influence of innovation and resource potential on costs (Fig. 6).

According to the results of the linear regression model, the following data were obtained: 1) the value of the determination coefficient was 63.9%, which is significant (more than 50%) for the object under study and the existing environment; 2) the value of the standard error was 10.67%; that is, the model on average was wrong by almost 11% and 3) the significance of the F-criterion emphasised the model's high degree of reliability.

However, the influence vector had a positive value; that is, with an increase in the value of innovation and resource potential, the costs would also increase.

This conclusion is generally natural, since measures to increase innovation and resource potential require significant costs (introduction of resource-saving technologies, increase in costs for research and development, etc.) but contradicts the goals of the enterprise to reduce costs and increase profits.

To determine the quantitative relationship between the innovation and resource potential and the resulting economic indicator (costs) under consideration, the elasticity coefficient was calculated. Its value was 4.66%, which means the following: with an increase in innovation and resource potential by 1%, costs would increase by 4.66%.

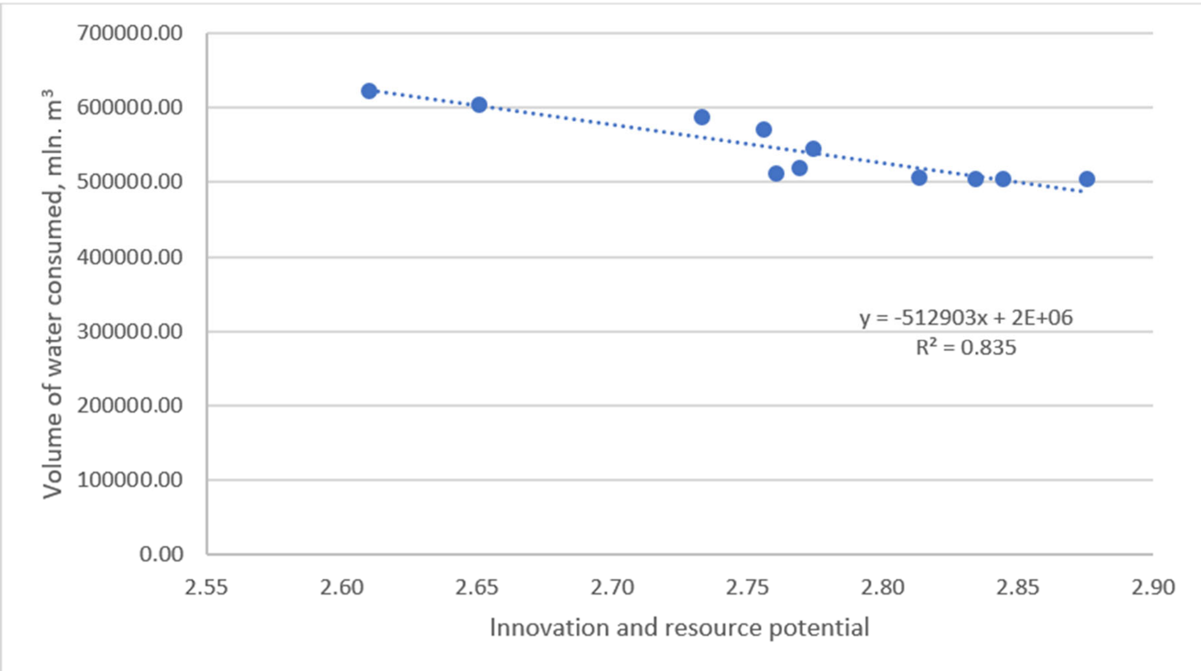

Figure 7. The relationship between indicators of innovation and resource potential and the volume of water consumed

This increase in costs would be compensated for by a significant increase in revenue, for which elasticity was also calculated. According to the results of the calculation, an increase in the innovation and resource potential by 1% would entail an increase in the company's revenue by 6.1%, which in turn confirms the effect of profit growth.

Model 6. The influence of innovation and resource potential on the volume of water consumed (Fig. 7).

This model is reliable and practically significant (the coefficient of determination exceeded 83%, and the standard error was 3.53%).

However, in this case, the impact vector (regression coefficient) had a negative value. Thus, with an increase in innovation and resource potential, the volume of water consumed would decrease.

5. Discussion

According to the results of the study, the first hypothesis was partially confirmed. That is, the impact of innovation and resource potential on profit was unambiguous. However, the modelling data indicated a temporary delay in the return on profit with the growth of innovation and resource potential, and accordingly, the absence of a clear correlation between the indicators when considering them in dynamics.

The second hypothesis was fully confirmed. Moreover, the reverse influence of the innovation and resource potential on water consumption was proven. This conclusion is logical, since the goal of the water supply enterprise is the rational use of water resources through the introduction of resource-saving technologies (closed-loop technologies, equipment with frequency regulation, flow meters, etc.). Moreover, water supply enterprises promote environmental policies and work with the public to rationalise water use. Therefore, the growth of innovation and resource potential will contribute to the reduction in water consumption.

Based on the analysis of the constructed regression models and the identification of the relationship between the innovation and resource potential and the resulting indicators, a set of recommendations and proposals aimed at improving and developing water supply enterprises was developed.

It should be noted that there is a problem with assessing innovation and resource potential, specifically the selection of indicators characterising a particular subpotential. For example, personnel indicators are present in the educational and personnel as well as organisational and managerial subpotentials, while technological indicators affect the information and technological as well as production and technology subpotentials. In the present study, the rationale for linking an indicator to a particular type of subpotential was related to the specifics of the activities of departments that primarily form such a subpotential. Therefore, subpotential assessments were focused on the expert opinions of the employees of these departments. Such a problem is inherent in complex studies of potential (Rudskaia and Rodionov, 2018; Fallah-Alipour et al., 2018) and does not arise in subject research (Nehrebecka, 2018; Stewart et al., 2018; Vasilieva et al., 2020; Popper et al., 2017).

The issue of selecting the resulting indicators for modelling and assessing the impact of innovation and resource potential is also debatable. The study took the most logical indicators from the point of view of the consequences of modelling and for the type of activity under consideration. Thefollowing scientists turned to some of them in their studies. Nehrebecka (2018) in his work assessing the financial potential of enterprises applied the dynamic econometric model, arguing that the financial constraints of the enterprise affect the level of sales in foreign markets and the behaviour

Table 5. Approaches to increase the efficiency of the use of innovation and resource potential

Subpotential	Directions of subpotential development
Educational and personnel	Improve the professional and qualification level of employees involved in the process of water treatment, transportation and water consumption through advanced training programs, additional higher education, competitions of professional skill, etc.
Research	Increasing the volume of positive results of research and development used to optimise the processes of water treatment, transportation and consumption in the forms of patents for inventions, descriptions of inventions, utility models, industrial designs, license agreements, etc.
Production and technical	Modernise equipment and structures, ensuring the replacement of old machinery and technologies in all divisions of the enterprise (main, auxiliary, servicing and management)
Information and technological	Automate most processes at the stages of water treatment, transportation and water consumption based on modern computer support
Financial and economic	Ensure the rational use of sources of financing of projects for modernisation (reconstruction) of water supply facilities and attraction of external investors (based on concession agreements and public–private partnerships)
Socioenvironmental	Ensure the stable quality of water supply services provided to consumers through the introduction of advanced achievements of scientific and technological progress (introduction of closed-cycle technologies to rationalise the use of resources at all stages of the water supply process); form a culture of careful water consumption among consumers of drinking water
Organisational and managerial	Improve the management system through the organisation of additional training programs for senior management and improve missions, vision, values and culture of the water supply enterprise aimed at rationalising the use of resources

of potential exporters. Vasilieva et al. (2020) evaluated development projects at chemical enterprises using key performance indicators, such as net discounted income, internal rate of return, profitability index and discounted payback period, to improve the efficiency of development and implementation of innovative products. Stewart et al. (2018) analysed the sustainable development of large companies, focusing on assessing the combined economic, social and environmental successes of a business.

However, in general, the results of the study showed the impact of innovation and resource potential on the selected financial, social and environmental indicators of the water supply enterprise.

6. Conclusion

The contributions of this study are as follows:

1. The key indicator reflecting the current and future capabilities of the enterprise is its potential. Under constant change and uncertainty from the external environment for the sustainable development of an enterprise, including water supply enterprises, it is advisable to consider innovation and resource potential and evaluate it.

2. The most complete idea of the innovation and resource potential of the enterprise can be given by an integral indicator that includes different types of potential (subpotentials). For the example of the water supply enterprise, seven subpotentials were selected, each of which characterises its own system of indicators developed by the authors. The study assessed the integral indicator.

3. The regression models constructed in the study showed the direct influence of the innovation and resource potential of the water supply enterprise on such effectiveness indicators as profit

and revenue and the reverse effect on the indicators of water loss during transportation and total water loss, costs and the volume of water consumed.

4. Of interest for further research is the assessment of the impact of human potential and automation on the potential of water supply enterprises. Since there is currently a rivalry between the educational and personnel as well information and technological potentials, the problem of the role of man in the future has become more relevant than ever.

References

Abouhamad, M., Abu-Hamd, M., 2020. Life cycle environmental assessment of light steel framed buildings with cement-based walls and floors. Sustainability 12, 1–17. https://doi.org/10.3390/su122410686

Bertuzzi, G., Ghisi, E., 2021. Potential for potable water savings due to rainwater use in a precast concrete factory. Water 13, 448. https://doi.org/10.3390/w13040448

Canci, E., 2021. Economic growth and innovation: An estimation of the innovation possibilities function. Brazilian Journal of Political Economy 41, 155–175. https://doi.org/10.1590/0101-31572021-2932

DECO, 2020. The Sustainable Development Goals Report 2020, United Nations publication issued by the Department of Economic and Social Affairs. Available at: https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf

Dobránsky, J., Pollák, M., Doboš, Z., 2019. Assessment of Production Process Capability in the Serial Production of Components for the Automotive Industry. Management Systems in Production Engineering 27, 255–258. https://doi.org/10.1515/mspe-2019-0040

EBC, 2018. Water & Wastewater Benchmark, public report of the IBO 2017 International Benchmarking exercise for Western Europe. Available at: https://www.waterbenchmark.org/news/Public-Report-of-IB2017-now-available-online!-/115

Fallah-Alipour, S., Boshrabadi, H.M., Mehrjerdi, M.R.Z., Hayati, D., 2018. A framework for empirical assessment of agricultural sustainability: The case of Iran. Sustainability 10, 4823. https://doi.org/10.3390/su10124823

Furtatova, A., Kamenik, L., 2018. Modeling features of sustainable urban development in modern conditions of water supply, in: MATEC Web of Conferences. International Science Conference SPbWOSCE-2017 Business Technologies for Sustainable Urban Development. https://doi.org/10.1051/matecconf/201817004002

Furtatova, A., Kamenik, L., 2019. Predictive analysis of water supply based on big data, in: Proceedings of the 33rd International Business Information Management Association Conference, IBIMA 2019: Education Excellence and Innovation Management through Vision 2020, 8762–8767. Available at: https://ibima.org/accepted-paper/predictive-analysis-of-water-supply-based-on-big-data/

Furtatova, A.S., Viktorova, N.G., 2020. Innovation-resource potential of water supply enterprise: terminology and meaning. Journal of Legal and Economic Studies 3, 187–196. https://doi.org/10.26163/GIEF.2020.72.76.031

Georgiev, I., Harvey, D.I., Leybourne, S.J., Robert Taylor, A.M., 2018. Testing for parameter instability in predictive regression models. Journal of Econometrics 204, 101–118. https://doi.org/10.1016/j.jeconom.2018.01.005

Graciano, J.E.A., Chachuat, B., Alves, R.M.B., 2018. Enviro-economic assessment of thermochemical polygeneration from microalgal biomass. Journal of Cleaner Production 203, 1132–1142. https://doi.org/10.1016/j.jclepro.2018.08.227

Hulio, Z.H., Jiang, W., Rehman, S., 2017. Technical and economic assessment of wind power potential of Nooriabad, Pakistan. Energy, Sustainability and Society 7. https://doi.org/10.1186/s13705-017-0137-9

Iacovidou, E., Millward-Hopkins, J., Busch, J., P. Purnell, J., Velis, C.A., Hahladakis, J.N. Zwirner, O., Brown, A., 2017. A pathway to circular economy: Developing a conceptual framework for complex value assessment of resources recovered from waste. Journal of Cleaner Production 168, 1279–1288. https://doi.org/10.1016/j.jclepro.2017.09.002

Martins, A.A., Simaria, M., Barbosa, J., Barbosa, R., Silva, D.T., Rocha, C.S., Mata, T.M., Caetano, N.S., 2018. Life cycle assessment tool of electricity generation in Portugal. Environment, Development and Sustainability 20, 129–143. https://doi.org/10.1007/s10668-018-0179-y

Moro, M.A., Andersen, M.M., Smets Barth, F., McKnight Ursula, S., 2019. National innovative capacity in the water sector: A comparison between China and Europe. Journal of Cleaner Production 210, 325–342. https://doi.org/10.1016/j.jclepro.2018.10.329

Nehrebecka, N., 2018. Sectoral risk assessment with particular emphasis on export enterprises in Poland. Zbornik Radova Ekonomskog Fakultet au Rijeci 36, 677–700. https://doi.org/10.18045/zbefri.2018.2.677

Park, S., Kim, J., 2021. The predictive capability of a novel ensemble tree-based algorithm for assessing groundwater potential. Sustainability 13, 1–19. https://doi.org/10.3390/su13052459

Peng, H., Lu, Y., 2012. Model selection in linear mixed effect models. Journal of Multivariate Analysis 109, 109–129. https://doi.org/10.1016/j.jmva.2012.02.005

Popper, R., Popper, M., Velasco, G., 2017. Towards a more responsible sustainable innovation assessment and management culture in Europe. Engineering Management in Production and Services 9, 7–20. https://doi.org/10.1515/emj-2017-0027

Rudskaia, I., Rodionov, D., 2018. The concept of total innovation management as a mechanism to enhance the competitiveness of the national innovation system, in: International Conference on Internet and e-Business (ICIEB), 246–251. https://doi.org/10.1145/3230348.3230349

Smith, G., 2015. Essential Statistics, Regression, and Econometrics, 2nd Edition, ed. Academic Press. https://doi.org/10.1016/C2014-0-04762-4

Song, J., Li, B., 2021. Nonlinear and additive principal component analysis for functional data. Journal of Multivariate Analysis 181, 104675. https://doi.org/10.1016/j.jmva.2020.104675

Stewart, R., Fantke, P., Bjørn, A., Owsianiak, M., Molin, C., Hauschild, M.X., Laurent, A., 2018. Life cycle assessment in corporate sustainability reporting: Global, regional, sectoral, and company-level trend. Business Strategy and the Environment 27, 1751–1764. https://doi.org/10.1002/bse.2241

UNESCO, 2020. United Nations World Water Development Report 2020: Water and Climate Change, Paris. Available at: https://en.unesco.org/themes/water-security/wwap/wwdr/2020#download

Vasilieva, E., Kudryavtseva, T., Skhvediani, A., 2020. Managing the efficiency of an innovative project in the chemical sector, in: International Scientific Conference on Digital Transformation on Manufacturing, Infrastructure and Service 940, 012046. https://doi.org/10.1088/1757-899X/940/1/012046

Список источников

Abouhamad, M., Abu-Hamd, M., 2020. Life cycle environmental assessment of light steel framed buildings with cement-based walls and floors. Sustainability 12, 1–17. https://doi.org/10.3390/su122410686

Bertuzzi, G., Ghisi, E., 2021. Potential for potable water savings due to rainwater use in a precast concrete factory. Water 13, 448. https://doi.org/10.3390/w13040448

Canci, E., 2021. Economic growth and innovation: An estimation of the innovation possibilities function. Brazilian Journal of Political Economy 41, 155–175. https://doi.org/10.1590/0101-31572021-2932

DECO, 2020. The Sustainable Development Goals Report 2020, United Nations publication issued by the Department of Economic and Social Affairs. Available at: https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf

Dobránsky, J., Pollák, M., Doboš, Z., 2019. Assessment of Production Process Capability in the Serial Production of Components for the Automotive Industry. Management Systems in Production Engineering 27, 255–258. https://doi.org/10.1515/mspe-2019-0040

EBC, 2018. Water & Wastewater Benchmark, public report of the IBO 2017 International Benchmarking exercise for Western Europe. Available at: https://www.waterbenchmark.org/news/Public-Report-of-IB2017-now-available-online!-/115

Fallah-Alipour, S., Boshrabadi, H.M., Mehrjerdi, M.R.Z., Hayati, D., 2018. A framework for empirical assessment of agricultural sustainability: The case of Iran. Sustainability 10, 4823. https://doi.org/10.3390/su10124823

Furtatova, A., Kamenik, L., 2018. Modeling features of sustainable urban development in modern conditions of water supply, in: MATEC Web of Conferences. International Science Conference SPbWOSCE-2017 Business Technologies for Sustainable Urban Development. https://doi.org/10.1051/matecconf/201817004002

Furtatova, A., Kamenik, L., 2019. Predictive analysis of water supply based on big data, in: Proceedings of the 33rd International Business Information Management Association Conference, IBIMA 2019: Education Excellence and Innovation Management through Vision 2020, 8762–8767. Available at: https://ibima.org/accepted-paper/predictive-analysis-of-water-supply-based-on-big-data/

Furtatova, A.S., Viktorova, N.G., 2020. Innovation-resource potential of water supply enterprise: terminology and meaning. Journal of Legal and Economic Studies 3, 187–196. https://doi.org/10.26163/GIEF.2020.72.76.031

Georgiev, I., Harvey, D.I., Leybourne, S.J., Robert Taylor, A.M., 2018. Testing for parameter instability in predictive regression models. Journal of Econometrics 204, 101–118. https://doi.org/10.1016/j.jeconom.2018.01.005

Graciano, J.E.A., Chachuat, B., Alves, R.M.B., 2018. Enviro-economic assessment of thermochemical polygeneration from microalgal biomass. Journal of Cleaner Production 203, 1132–1142. https://doi.org/10.1016/j.jclepro.2018.08.227

Hulio, Z.H., Jiang, W., Rehman, S., 2017. Technical and economic assessment of wind power potential of Nooriabad, Pakistan. Energy, Sustainability and Society 7. https://doi.org/10.1186/s13705-017-0137-9

Iacovidou, E., Millward-Hopkins, J., Busch, J., P. Purnell, J., Velis, C.A., Hahladakis, J.N. Zwirner, O., Brown, A., 2017. A pathway to circular economy: Developing a conceptual framework for complex value assessment of resources recovered from waste. Journal of Cleaner Production 168, 1279–1288. https://doi.org/10.1016/j.jclepro.2017.09.002

Martins, A.A., Simaria, M., Barbosa, J., Barbosa, R., Silva, D.T., Rocha, C.S., Mata, T.M., Caetano, N.S., 2018. Life cycle assessment tool of electricity generation in Portugal. Environment, Development and Sustainability 20, 129–143. https://doi.org/10.1007/s10668-018-0179-y

Moro, M.A., Andersen, M.M., Smets Barth, F., McKnight Ursula, S., 2019. National innovative capacity in the water sector: A comparison between China and Europe. Journal of Cleaner Production 210, 325–342. https://doi.org/10.1016/j.jclepro.2018.10.329

Nehrebecka, N., 2018. Sectoral risk assessment with particular emphasis on export enterprises in Poland. Zbornik Radova Ekonomskog Fakultet au Rijeci 36, 677–700. https://doi.org/10.18045/zbefri.2018.2.677

Park, S., Kim, J., 2021. The predictive capability of a novel ensemble tree-based algorithm for assessing groundwater potential. Sustainability 13, 1–19. https://doi.org/10.3390/su13052459

Peng, H., Lu, Y., 2012. Model selection in linear mixed effect models. Journal of Multivariate Analysis 109, 109–129. https://doi.org/10.1016/j.jmva.2012.02.005

Popper, R., Popper, M., Velasco, G., 2017. Towards a more responsible sustainable innovation assessment and management culture in Europe. Engineering Management in Production and Services 9, 7–20. https://doi.org/10.1515/emj-2017-0027

Rudskaia, I., Rodionov, D., 2018. The concept of total innovation management as a mechanism to enhance the competitiveness of the national innovation system, in: International Conference on Internet and e-Business (ICIEB), 246–251. https://doi.org/10.1145/3230348.3230349

Smith, G., 2015. Essential Statistics, Regression, and Econometrics, 2nd Edition, ed. Academic Press. https://doi.org/10.1016/C2014-0-04762-4

Song, J., Li, B., 2021. Nonlinear and additive principal component analysis for functional data. Journal of Multivariate Analysis 181, 104675. https://doi.org/10.1016/j.jmva.2020.104675

Stewart, R., Fantke, P., Bjørn, A., Owsianiak, M., Molin, C., Hauschild, M.X., Laurent, A., 2018. Life cycle assessment in corporate sustainability reporting: Global, regional, sectoral, and company-level trend. Business Strategy and the Environment 27, 1751–1764. https://doi.org/10.1002/bse.2241

UNESCO, 2020. United Nations World Water Development Report 2020: Water and Climate Change, Paris. Available at: https://en.unesco.org/themes/water-security/wwap/wwdr/2020#download

Vasilieva, E., Kudryavtseva, T., Skhvediani, A., 2020. Managing the efficiency of an innovative project in the chemical sector, in: International Scientific Conference on Digital Transformation on Manufacturing, Infrastructure and Service 940, 012046. https://doi.org/10.1088/1757-899X/940/1/012046

The article was submitted 2.05.2021, approved after reviewing 29.06.2021, accepted for publication 10.07.2021.
Статья поступила в редакцию 2.05.2021, одобрена после рецензирования 29.06.2021, принята к публикации 10.07.2021.

About the authors:
1. Alina Furtatova, lecturer, Graduate School of Industrial Economics, Peter the Great St.Petersburg Polytechnic University, St.Petersburg, Russia, https://orcid.org/0000-0002-2796-5174, alina_furtado@mail.ru
2. Natalia Victorova, Doctor of economics, professor, Graduate School of Industrial Economics, Peter the Great St.Petersburg Polytechnic University, St.Petersburg, Russia, https://orcid.org/0000-0002-7355-3541, viktorova_ng@spbstu.ru
3. Evgenii Konnikov, PhD in Economics, associate professor, Graduate School of Industrial Economics, Peter the Great St.Petersburg Polytechnic University, St.Petersburg, Russia, https://orcid.org/0000-0002-4685-8569, konnikov_ea@spbstu.ru
Информация об авторах:
1. Алина Сергеевна Фуртатова, преподаватель, Санкт-Петербургский политехнический университет Петра Великого, Санкт-Петербург, Россия, https://orcid.org/0000-0002-2796-5174, alina_furtado@mail.ru
2. Наталья Геннадьевна Викторова, доктор экономических наук, профессор, Высшая инженерно-экономическая школа, Санкт-Петербургский политехнический университет Петра Великого, Санкт-Петербург, Россия, https://orcid.org/0000-0002-7355-3541, viktorova_ng@spbstu.ru
3. Евгений Александрович Конников, кандидат экономических наук, доцент, Высшая инженерно-экономическая школа, Санкт-Петербургский Политехнический университет Петра Великого, Санкт-Петербург, Россия, https://orcid.org/0000-0002-4685-8569, konnikov_ea@spbstu.ru