Original Paper
doi 10.15826/recon.2024.10.1.002
UDC 332.1
JEL Q56, R11, O15, P36, Q57

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The circular economy skills: regional dimension

ABSTRACT
Relevance. In the pursuit of sustainable development, the circular economy takes precedence as a fundamental imperative for industrial transformation. The current trend in the development of the circular economy concept is to place the main focus on the technological support of circularization and the corresponding innovations in business models, while the decisive role people play in this model of economy is often overlooked. Individuals with specialized knowledge, skills, and values are essential for developing and implementing circular models, making effective management decisions, and promoting rational consumption patterns. The demand for circular skills and the availability of relevant competencies can significantly differ across regions, necessitating further in-depth study.
Research objective. The paper is aimed at developing a new methodological approach to the study of circular economy skills at the regional level. This approach considers these skills in terms of both employer demand and their incorporation into master's degree programs, accounting for regional specifics.
Data and methods. The study employed a comprehensive approach, integrating theoretical methods with empirical analysis. Scientometric and content analysis identified taxonomies of circular economy skills, and employers' personnel needs were examined through the analysis of the HeadHunter job site using Python software. Additionally, the study encompassed an analysis of educational programs from official websites of universities in southern Russian regions.
Results. A new approach to the study of supply and demand of circular economy skills at the regional level has been proposed and tested. As a result, it was determined that there is a demand for sustainable development specialists in various industries in the Russian labor market, which varies across different regions of the country. The relevant skills are included in the master's degree programs offered by universities. There is a need for greater involvement of regional authorities in shaping educational demands presented to universities, as this is essential for generating demand in the job market for the corresponding competencies.
Conclusions. To better achieve targets in sustainable development and facilitate the transition to a circular economy, it is essential to promote a balanced development of all the relevant skills and behavioral patterns. To ensure this, it is important to involve regional authorities in shaping the demand for these skills.

KEYWORDS
circular economy, Russian regions, sustainable development, Industry 4.0, education, circular economy skills, digital economy, regional conditions, master's degree programs, south of Russia

FOR CITATION
Nikitaeva, A. Yu., Bondarev, M. G., Masych, M. A., Dolgova, O. I. (2024). The circular economy skills: regional dimension. *R-Economy*, 10(1), 21–40. doi: 10.15826/recon.2024.10.1.002

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Компетенции циркулярной экономики: региональное измерение

АННОТАЦИЯ
Актуальность. Устойчивое развитие считается одним из главных императивов промышленной трансформации. Экономика замкнутого цикла является приоритетной моделью для реализации устойчивого развития. Однако в настоящее время при развитии экономики замкнутого цикла

КЛЮЧЕВЫЕ СЛОВА
циркулярная экономика, регионы России, устойчивое развитие, Индустрия 4.0,

Online ISSN 2412-0731

основное внимание сосредоточено на технологической поддержке циркуляризации и соответствующих инновациях в бизнес-моделях. Тогда как решающую роль в становлении и развитии экономики замкнутого цикла играют люди. Только люди, обладающие специальными знаниями, навыками и ценностями, могут разрабатывать и внедрять циклические модели, принимать соответствующие управленческие решения и применять модели рационального потребления. При этом спрос на циркулярные навыки и предложение соответствующих компетенций может существенно варьироваться в различных регионах, что требует более глубокого изучения.
Цель исследования. Работа нацелена на предложение нового методического подхода к исследованию навыков экономики замкнутого цикла на региональном уровне за счет их комплексного учета как в части спроса со стороны работодателей, так и с позиции отражения соответствующих компетенций в программах магистратуры.
Данные и методы. В исследовании использован комплекс теоретических и прикладных методов. На основе наукометрического и контент-анализа литературы были определены таксономии навыков экономики замкнутого цикла. Чтобы соотнести теоретические и практические навыки и определить потребность производителей в персонале для устойчивого развития, был проведен эмпирический анализ самого популярного сайта по поиску работы и сотрудников в России – HeadHunter с использованием программного обеспечения Python. Для анализа образовательных программ российских университетов на Юге России были использованы данные, представленные на официальных сайтах вузов.
Результаты. Предложен и апробирован новый подход к исследованию спроса и предложения навыков экономики замкнутого цикла на региональном уровне. В результате применения данного подхода определено, что на рынке труда существует спрос на специалистов по устойчивому развитию в различных отраслях промышленности, который варьируется в регионах страны. Соответствующие навыки включены в образовательные программы магистратуры. При этом требуется большее включение региональных органов власти в формирование образовательного запроса университетам для последующей генерации спроса на соответствующие компетенции на рынке труда.
Выводы. Для более полного достижения целей в области устойчивого развития и перехода к циркулярной экономике требуется сбалансированное развитие всех видов навыков и моделей поведения в экономике замкнутого цикла с более активным вовлечением в формирование запроса на их формирование региональных органов власти.

образование, навыки циркулярной экономики, цифровая экономика, региональные условия, программы магистратуры, Юг России.

ДЛЯ ЦИТИРОВАНИЯ
Nikitaeva, A. Yu., Bondarev, M. G., Masych, M. A., Dolgova, O. I. (2024). The circular economy skills: regional dimension. *R-Economy*, 10(1), 21–40. doi: 10.15826/recon.2024.10.1.002

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循环经济能力：区域层面

摘要
现实性：可持续发展被认为是工业转型的当务之急。循环经济是实现可持续发展的优先模式。然而，目前循环经济发展的重点在于为循环化提供技术支持以及进行相关的商业模式创新。而人在循环经济的建立和发展中起着至关重要的作用。只有具备专业知识、技能和价值观的人才，才能开发和实施循环模式，做出适当的管理决策，并应用可持续的消费模式。同时，不同地区对循环技能的需求和相关能力的供应可能存在很大差异，这需要进行更深入的研究。
研究目标：这项工作旨为区域层面的循环经济技能研究提出一种新的方法论。既考虑到雇主的需求，又能在硕士课程中体现出相关能力。
数据与方法：研究采用了一套理论和应用方法。在对文献进行科学计量和内容分析的基础上，确定了闭环经济技能分类标准。为了将理论和实践技能联系起来，确定制造商对可持续发展人才的需求，文

关键词：
循环经济、俄罗斯地区、可持续发展、工业 4.0、教育、循环经济技能、数字经济、地区条件、硕士课程、俄罗斯南部

Online ISSN 2412-0731

章使用 Python 软件对俄罗斯最受欢迎的工作和雇员搜索网站——HeadHunter 进行了实证分析。为了分析俄罗斯南部各大学的教育计划，研究使用了各大学官方网站提供的数据。
研究结果：我们提出并测试了一种研究区域层面循环经济技能需求和供给的新方法。研究结果是，劳动力市场对各行各业的可持续发展专家都有需求，这种需求在全国各地区各有不同。而相关技能也已纳入硕士学位课程的教学计划。同时，有必要让地方当局更多地参与大学的教育计划，以便大学能满足劳动力市场对相关能力的需求。
结论：未来应更充分地实现可持续发展目标，并实行其向循环经济的过渡。这必须明确并形成均衡发展循环经济的各类技能和行为，并让地方当局更多地、更积极地参与其中。

供引用
Nikitaeva, A. Yu., Bondarev, M. G., Masych, M. A., Dolgova, O. I. (2024). The circular economy skills: regional dimension. *R-Economy*, 10(1), 21–40. doi: 10.15826/recon.2024.10.1.002

Introduction

Nowadays there is a general consensus that integrating sustainability principles into national and regional economic strategies is crucial. This tendency is evident in key actions and documents such as the UN's Sustainable Development Goals, programs and indicators for monitoring progress, and the rise of ESG reporting. Meanwhile, the circular economy model is recognized as one of the most effective approaches to the transition toward sustainable development (Geissdoerfer et al., 2017; Terra dos Santos et al., 2022; Piscicelli, 2023; Gil-Lamatav and Latorre, 2022). The circular economy "represents a new economic paradigm that aims to transition from the traditional linear economic model to a circular economic one. It seeks to redesign products, supply chains, and consumption patterns to make it economically feasible to implement circular loops" (Hondroyiannis et al., 2024).

Such a model assumes that closed production and sales cycles are created in the economy, attention is focused on the processing and reuse of resources, and the key trend is associated with a reduction in inputs, along with minimizing waste streams and greenhouse gas emissions into the atmosphere due to the fact that the "outputs" of any process are not wasted but become "inputs" for other processes (Nautiyal and Goel, 2021). In other words, a closed-loop economy is an economic system that is structured with the goals of reducing waste and resource consumption in mind (Prieto-Sandoval et al. 2018).

The circular economy aims to prevent resource depletion, close energy and material cycles, and foster sustainable development by embracing cyclical and regenerative environmental innovations in legislation, production, and consumption (Prieto-Sandoval et al., 2018). However, presently, the influence of the circular economy remains relatively insignificant in both country-level and industry-level transformations (Prieto-Sandoval et al., 2018; Shirvanimoghaddam et al., 2020; Saccani et al., 2023).

Despite its appealing concept, implementing a closed-loop economy requires a comprehensive set of practical solutions in economic, technological, organizational, and managerial aspects. Current research in closed-loop economics primarily focuses on new production technologies and Industry 4.0 technologies (Ren et al., 2023), institutional factors like strategies, regulations, and practices (Maher et al., 2023), digital circularization technologies, and distributed value chains (Cagno et al., 2021; Chauhan et al., 2022; Bressanelli et al., 2022; Väisänen et al., 2019), as well as digital business models (Geissdoerfer et al., 2020), and the drivers and constraints for establishing an appropriate model (Oluleye et al., 2023; Hofmann Trevisan et al., Tan et al., 2022). However, there's a notable gap in addressing the question of who will be responsible for creating circular models and, concurrently, generating demand for products produced in closed chains.

The alignment between the content of strategies and projects for establishing a circular economy and promoting sustainable economic development does not sufficiently consider the quantity and characteristics of individuals who should possess relevant competencies over varying time periods. Moreover, there is a need to assess the current and future availability of human capital for supporting circular models. In this study, sustainable skills refer to competencies addressing the 'triple bottom line' (social, environmental, and economic) (Straub et al., 2023), while circular skills specifically target aspects such as "cycling, extending, intensifying, and/or dematerializing material and energy loops to reduce resource inputs and minimize waste and emissions in an or-

Online ISSN 2412-0731

ganizational system" (Geissdoerfer et al., 2020). However, in the empirical analysis of competency demand in the labor market, this study does not draw a clear distinction between these sets of skills.

This study aims to develop a comprehensive methodological approach for assessing closed-loop economics skills. The primary focus is on understanding these skills by considering both employer demand and their reflection in relevant competencies within master's degree programs, taking into account regional specifics.

The study is structured around the following interconnected objectives: to define the essence and content of circular economy skills, building upon existing research in this thematic area; to analyze the demand for circular economy jobs and skills across various regions of Russia, with a more detailed examination of the south of Russia; and, finally to determine the extent to which circular economy skills are included in master's degree programs, evaluating the availability of supply and its alignment with the labor market demand in the south of Russia.

Theoretical framework

Since its inception as a concept, the circular economy has received quite a lot of attention in academic literature. Interestingly, an analysis of research keywords on the topic, using the intelligent system wisdom.ai, reveals a predominant focus on technical aspects and a prioritized emphasis on closing technological cycles while the "human" component of circularization does not seem to hold a high priority in research endeavors[1]. A content analysis of publications on the circular economy allowed us to identify both key areas of research in this field and aspects related to the study of the role of human resources in circularization.

Modern researchers pay much attention to the fact that the transition to circular models changes the business models and ways of functioning of companies, especially in the manufacturing sector (Suchek et al., 2021; Santa-Maria et al., 2021), based on the introduction of appropriate innovations (Suchek et al., 2021; Sehnem et al., 2022). It is also important to keep in mind the fact that establishing a circular economy necessitates transformations not only on the production side but also on the consumption side (De los Rios et al., 2017; Millard et al., 2018; Hobson et al., 2021; Arranz et al., 2023; Morseletto, 2023).

There is a group of studies devoted to various organizational components in the development of the circular economy. For example, Chowdhury et al. (2022), based on the study of literature on circular economy, human resource management, innovation, and sustainable development, investigated the interrelationships between organizational factors such as leadership, innovation, culture, and skills and their impact on the introduction of circular economy practices by small and medium-sized enterprises (SMEs). After surveying 205 employees from SMEs in Vietnam and analyzing responses using a structural equations model, researchers demonstrated that organizational leadership plays a crucial role in fostering a culture of innovation. This, in turn, contributes to the successful implementation of circular economy practices through the "center and spoke" strategy, leading to enhanced sustainable productivity among small and medium-sized businesses in the examined country. The study recommends implementing knowledge-sharing strategies, forming cooperation-focused working groups within and between SMEs, and developing corresponding information systems.

In the same vein, and for a business of a similar scale, Soni et al. (2023) studied the circular economy through the prism of adaptive distributed leadership. Based on the analysis of 30 semi-structured interviews with managers SMEs engaged in intensive technological processes in India, the authors showed that distributed leadership facilitates the introduction of a circular economy. They emphasize the importance of an environment in which separation and delegation of authority, decision-making, sharing of authority, and a spirit of cooperation are allowed, which invariably develops trust, skill sets, and self-confidence in employees, contributing to the introduction of a circular economy.

Erdiaw-Kwasie et al. (2023) also considered the influence of organizational-level variables (institutional factors, contextual factors, and strategic factors) on the introduction of a circular economy in service sector organizations. The study showed that organizational factors lay the foundation for the introduction of circular economy

[1] Circular economy. Wisdom.ai. Retrieved from: https://www.wizdom.ai/topic/circular_economy/31666505 (Date of access 10.11.23)

Online ISSN 2412-0731

practices, and the knowledge of the management of organizations about the circular economy (493 senior employees from 267 Ghanaian service organizations were interviewed) strengthens the link between organizational factors and the introduction of circularization practices.

Van Opstal and Borms (2023), linking the introduction of the circular economy with startups as engines necessary for circular innovations, showed that young startupers tend to focus more on circular strategies related to design and less on waste recycling. It was also found that waste disposal strategies are more often chosen by aspiring entrepreneurs without higher education. Older entrepreneurs were also found to be less inclined to use cyclical strategies while female entrepreneurs were less inclined to combine several cyclical strategies.

Similar results confirming the greater involvement of Generation Z in issues of circulation were obtained by Gazzola et al. (2020). According to Hojnik et al. (2023), whose study focused on Slovenian companies, young adultes are more receptive to new green technologies and digitalization (closely related to eco-innovation and circular economy).

Another group of studies specifically concentrates on the skills necessary for establishing a circular economy. According to Borms et al. (2023), designing to minimize material consumption heightens the demand for transportation and logistics skills, digitalization amplifies the need for research and development (R&D) and information technology (IT) skills, and waste disposal requires technical knowledge. Additionally, an entrepreneur's gender, age, and experience influence the requisite skills.

Based on the fact that the implementation of circular initiatives requires certain capabilities and knowledge, Johnson (2022) determines the need to fill the skills gap for the implementation of circular-oriented innovations. The researcher substantiates that skills for circular-oriented innovations include a combination of tangible and intangible aspects, such as space, tools, storage for repairs and refurbishment, as well as management, and, in addition, knowledge, skills, shared values, and vision for the practical implementation of new circular models. The necessary competencies are based on the corporate values of cooperation and building partnerships.

Schlüter et al. (2022) emphasize the crucial role of industrial symbiosis in shaping a circular economy, highlighting the need for a third-party facilitator in constructing and organizing resource exchange. The authors specifically identify five key skills essential for this facilitator role: social skills, work approach, motivation and interest, ethics and responsibility, as well as knowledge.

Straub et al. (2023) focus on human resources and offer a comprehensive taxonomy of skills for startups covering the transition to a cyclical economy. They use a cluster analysis of skill profiles reported by 2,407 employees working in circular startups. The taxonomy describes 40 skills in six categories: business innovation, operations, social aspects, systems, digitization, and technical issues.

Our literature review indicates that, to date, researchers worldwide have shown interest in the role of humans in shaping a circular economy, encompassing aspects such as skills, professions, positions, educational schemes, both from the production and consumption sides. However, there remains an unexplored aspect concerning a comprehensive study of the supply and demand for circular economy skills. This article aims to address this research gap and provide insights into the issue.

Methodology and data

We examined the demand for circular economy skills both from employers and in the context of reflecting relevant competencies in master's degree programs, considering regional nuances. The methodology involved identifying taxonomies of circular economy skills through a theoretical literature analysis. To bridge theoretical and practical skills and ascertain manufacturers' personnel needs for sustainable development, we analyzed the popular job search site, HeadHunter, which boasts a monthly audience of 68.8 million people, making it a suitable resource.

The study comprised two stages: the first collected data on vacancies nationwide, while the second delved into the specifics of southern Russian regions. The first stage revealed regional differentiation in circular economy skills demand, while the second provided deeper insights into the demand for employees with a sustainable development focus.

For the search, the rigidly formulated query "sustainable development" was used, which is necessary to find an exact match. It is important to note that despite the rigid form of the query,

Online ISSN 2412-0731

the HeadHunter search engine performs a search taking into account the various word forms of the specified words. Since the search aimed at finding the specified phrase only in the name of the vacancy did not make it possible to obtain data on vacancies not directly related to sustainable development but placed by companies implementing the principles of sustainable development at their enterprises, the following search criteria were set: the presence of the phrase "sustainable development" in the name of the vacancy and/or in the text vacancies. In order to work with a large amount of data, a Python software was written during the research that performed the search and selection of objects with a certain necessary class from the code of a web page.

Furthermore, we conducted an analysis of the educational programs offered by Russian universities to evaluate the incorporation of circular economy skills. Considering the significant differentiation among both the country's regions and the demand for sustainable development and circularity skills, we focused on the South of Russia for this segment of the empirical study. The selection of regions for analysis was based on common characteristic features in the regional specialization of Southern Russia, utilizing data from the Atlas of Economic Specialization of Russian Regions by the Higher School of Economics (Abashkin et al., 2021). Subsequently, we examined the regional profiles of the Southern Federal District.

Based on the analysis results, the following regions of the Russian Federation were included in the final sample: Rostov region, Krasnodar region, Volgograd region, Astrakhan region, The Republic of Crimea, The federal city of Sevastopol.

These regions are characterized by a high degree of industrial sector development, which is significantly influenced by the adoption of the federal project "Closed-Loop Economy"[2] and the implementation of the federal project "Ecology". Preceding studies revealed a significant potential for the circularization of these regions (Nikitaeva et al., 2022). The Republic of Adygea and the Republic of Kalmykia were not included in this study, as their industrial sector is less developed than in other regions of southern Russia, and they do not represent any industries of national importance that are present in the selected regions.

The basis for the selection of universities for the analysis of the competence profile of educational programs in terms of circular economy skills was the analysis of the profiles of the regions of the Southern Federal District in the context of their regional specialization. Further selection of universities was based on the selected regions and on the basis of ratings such as the Moscow international rating "Three University Missions" for 2022[3], the rating of the best universities in Russia RAEX-100 for 2022[4], the local rating of universities in the Southern Federal District (2023)[5], and also the university's participation in the program "Priority 2030"[6]. This is due to the fact that the topic of the circular economy is quite new in its content; accordingly, educational programs require the rapid incorporation of the results of scientific research, which are traditionally carried out by universities with higher rating indicators. As a result of the analysis, the following 10 universities were selected:

– 3 universities were selected in Rostov Region: Southern Federal University, Platov South Russian State Polytechnic University (NPI), and Don State Technical University;

– 2 universities in Volgograd Region: Volgograd State University and Volgograd State Technical University;

– 2 universities in Krasnodar region: Kuban State University and Kuban State Technological University;

– 1 university in Astrakhan Region: Astrakhan State University;

– 1 university in the Republic of Crimea: the Crimean Federal University n.a. V.I. Vernadsky;

– 1 university in the federal city of Sevastopol: Sevastopol State University.

[2] Passport of the federal project "Closed-Loop Economy", Municipal Solid Waste magazine, 2022, news.solidwaste.ru. Retrieved from https://news.solidwaste.ru/wp-content/uploads/2022/07/EZTs_pasport.pdf (Date of access 19.04.23)

[3] Moscow international rating "Three Missions of the University ", Mosiur, 2023, mosiur.org. Retrieved from: https://mosiur.org/ (Date of access 19.04.23)

[4] Ranking: Rating of the best universities in Russia RAEX-100 (2022), Raex-rr, 2022, raex-rr.com. Retrieved from https://raex-rr.com/education/russian_universities/top-100_universities/2022/ (Date of access 12.03.23)

[5] Ranking: Local ranking of universities in the Southern Federal District (2023), Raex-rr, 2023, raex-rr.com. Retrieved from https://raex-rr.com/education/local_university_rating/local_university_rating_YUFO/2023/ (Date of access 14.04.23)

[6] Priority2030, 2023, priority2030.ru. Retrieved from: https://priority2030.ru/ (Date of access 11.04.23)

Online ISSN 2412-0731

Table 1

TOP 10 skills according to the World Economic Forum in 2015, 2020 and 2025

№	2015	2020	2025
1	Comprehensive problem solving	Comprehensive problem solving	Analytical thinking and innovation
2	Interaction with people	Critical thinking	Active learning and learning strategies
3	The ability to manage people	Creativity	Solutions to complex problems
4	Critical thinking	The ability to manage people	Critical thinking and analysis
5	Negotiation skill	Interaction with people	Creativity, originality and initiative
6	Quality control	Emotional Intelligence	Leadership and social influence
7	Client orientation	Ability to analyze and make decisions	Technology use, monitoring and control
8	Ability to analyze and make decisions	Client orientation	Creating technologies and programming
9	Active listening	Negotiation skill	Endurance, stress resistance and flexibility
10	Creativity	Flexibility of thinking	Logical reasoning, problem solving and idea generation

Source: World Economic Forum 2020. Retrieved from: https://intelligence.weforum.org/topics/ (Date of access 15.04.23)

The subsequent stage involved analyzing master's degree programs at the aforementioned universities to identify competencies related to the circular economy. Master's programs were chosen due to their focus on competencies in mastering green technologies and developing and utilizing circular business models, which are more intricate than traditional linear models. Additionally, the shorter cycle for creating and implementing master's degree programs, compared to bachelor's and specialty programs, was taken into consideration.

The analysis methodology for master's degree programs was based on a competency sample extracted from the main professional educational programs across various fields implemented at the university. Descriptions of these programs included keywords such as "sustainable development," "ecology," "environmental safety," "nature management," "environmental protection," "pollution of the atmosphere," and others. Key focuses encompassed "depletion of natural resources," "destruction of natural resources," "engineering and environmental work," "rational use of natural resources," "supply chains," "technological processes," "business models," "application of environmental biotechnologies," "environmental impact of human activities," "environmental technologies," "rational use" of resources, "creation of new models of objects based on knowledge of engineering geology," "sustainable environment," "environmental management," and others geared toward sustainable development.

It's noteworthy that master's programs across all areas share a set of universal competencies representing cross-cutting skills (or soft skills) mandatory for all students. These include systemic and critical thinking, project development and implementation, teamwork and leadership, communication, self-organization, and self-development. However, the selection of educational programs was based on general professional and specific professional competencies that best reflected the program's specifics and its contribution to the development of circular economy skills.

Results

Circular Economy Skills

The active expansion of the principles of a circular economy in various sectors is faced with a shortage of qualified personnel, including the lack of necessary skills that meet the requirements of a closed-loop economy (Ermolaeva, 2021)[7]. In this regard, there is a need to correlate the circular skills and competencies that are in demand in the labor market with the skills and competencies that the education system currently provides. This requires the identification of skills in the circular

[7] Strietska-Ilina O., A sustainable greener future needs green employment skills, International Labour Organization (ILO), 2023, www.ilo.org. Retrieved from https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_709084/lang--en/index.htm (Date of access 12.04.2023)

Online ISSN 2412-0731

economy[8] (Masych, 2019; Masych, 2022). According to the World Economic Forum, it is possible to trace the top 10 skills of highly effective people by year (Table 1).

When analyzing the forecast of the TOP 10 skills of 2025, we see that only two positions in the ranking are assigned to hard skills aimed at mastering technology and programming. The remaining eight points are occupied by soft skills. Moreover, such skills as critical thinking, analytical abilities and willingness to solve problems have been in the top 10 for several years in a row. There are also several skills that were included in the rating for the first time: active learning, flexibility and stress tolerance, which is associated with the spread of remote work and the unstable situation in the world.

Within the framework of the European project on circular economy and education "Three C: Creating Competencies for a circular economy", a matrix of competencies for a closed-loop economy was developed (based on Bloom's Taxonomy)[9]. It is represented by five levels in the context of three structures: knowledge, actions, and feelings. The name of the project (Three C) is based on the main three goals defined as: a) to define competencies in the field of circular economy; b) to develop a didactic approach to education in the field of circular economy; c) create assessment tools (respectively: Creating Competencies for a Circular Economy). Moreover, the basis of this concept is that system thinking is used to measure knowledge and actions, system design is used to measure actions, and multi-perspective thinking is used to measure feelings.

Another of the taxonomies of skills for a losed-loop economy is their classification into general, stable, and circular (circular) (Straub et al., 2023; Pieroni et al., 2020; Burger et al., 2019). In this case, the authors refer to general skills acquired directly at the workplace, for example, the ability to perform tasks; sustainable skills include social, economic, and environmental skills; and circular skills include hard skills necessary to work in a closed-loop economy, such as the ability to work with projects to optimize material and energy cycles to reduce resource costs and waste leakage and emissions from the system.

Straub et al. (2023) also identify such groups of skills as "business innovation skills (developing and seizing innovative business propositions); operational business skills (solving business problems in real-world settings and allocating resources accordingly); social skills (working constructively with people to achieve goals); system skills (understanding, monitoring, and improving socio-technical systems); digital skills (developing and managing IT and data); technical skills (applying technical knowledge in relevant business domains)" (Straub et al., 2023). Furthermore, each of the outlined skill groups for the advancement of the circular economy (such as sustainable development, environmental management, environmental storytelling, supply chain management, eco-friendly design, environmental engineering, etc.) is incorporated. After delineating these taxonomies, it becomes crucial to discern the skills and professions that are sought after by employers.

Demand for circular economy skills and professions

We analyzed vacancies on the topic of sustainable development posted on the HeadHunter website on April 20, 2023, in different regions. As of April 20, 2023, 816 vacancies related to sustainable development were found throughout Russia. Of these, the phrase "sustainable development" was present in the name of only 25 vacancies (16 of them were placed in Moscow, 2 in St. Petersburg, and 1 vacancy was presented in Rostov-on-Don, Voronezh, Omsk, Stupino, Tyumen, Kemerovo, and Yuzhno-Sakhalinsk). Most these vacancies were managerial positions. We found 7 manager vacancies,5 project manager vacancies and 3 project engineers, 4 specialist vacancies, 2 analyst vacancies.

It is also important to note that among these vacancies, there were vacancies not only for senior management positions but also for positions for interns. The remaining vacancies were not directly related to sustainable development, but employers noted in the text of the vacancy either the need to work with research or documentation related to sustainable development or the fact that

[8] Future Proof for 2020: Do You Have the Top 5 Sustainability Skills to Survive? Net impact, 2017, netimpact.org. Retrieved from https://netimpact.org/blog/future-proof-for-2020-do-you-have-the-top-5-sustainability-skills-to-survive (Date of access 19.03.23)

[9] Circular Economy and Education Conference Report, The GREEEN Network, 2016, greeen-eu.net. Retrieved from: https://greeen-eu.net/wp-content/uploads/2014/02/threeC-report-Porto-event.pdf (Date of access 15.04.23)

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their company adheres to the principles of sustainable development in its operations.

At the moment, the demand for positions related to sustainable development is uneven for different regions of the Russian Federation (Fig. 1). The largest number of vacancies—140—are found in the capital, which is explained by its high level of economic development. The second place is occupied by the federal city of St. Petersburg with 77 vacancies and the third place, by Krasnodar region with 77 vacancies. In addition, Irkutsk Region and the Trans-Baikal region have 69 and 62 published vacancies, respectively.

It is also possible to distinguish groups of regions in which from 31 to 60 vacancies were presented on April 20: Krasnoyarsk and Moscow regions, and the Republic of Bashkortostan. There is a higher demand for sustainable personnel in the Central, Siberian, Southern, and Volga Federal Districts. However, in many regions of the North Caucasus District and the Ural Federal District, the widespread implementation of the concept of sustainable development is still not prevalent.

Figure 2 shows the distribution of vacancies in federal districts; the average value for the district is presented, and the number of regions in which there is no demand for sustainable personnel is highlighted in red. This analysis allows us to conclude that the implementation of the concept of sustainability is uneven, even within one federal district. The Siberian and Southern Federal Districts are developing most evenly, with 30% of the regions having a demand for specialists with sustainable development skills. The average number of vacancies in the district is also the largest. Despite the fact that Moscow has the highest demand for stable personnel, in other regions of the Central Federal District there is much less demand. As the diagram illustrates, if you exclude the capital, the structure of demand in the Central Federal District is closest to the Volga region. The lowest demand for stable personnel is demonstrated by the regions of the North Caucasus Federal District, in which only 5 vacancies were placed in the Karachay-Cherkess Republic, while in other regions of the district the demand was zero. This sit-

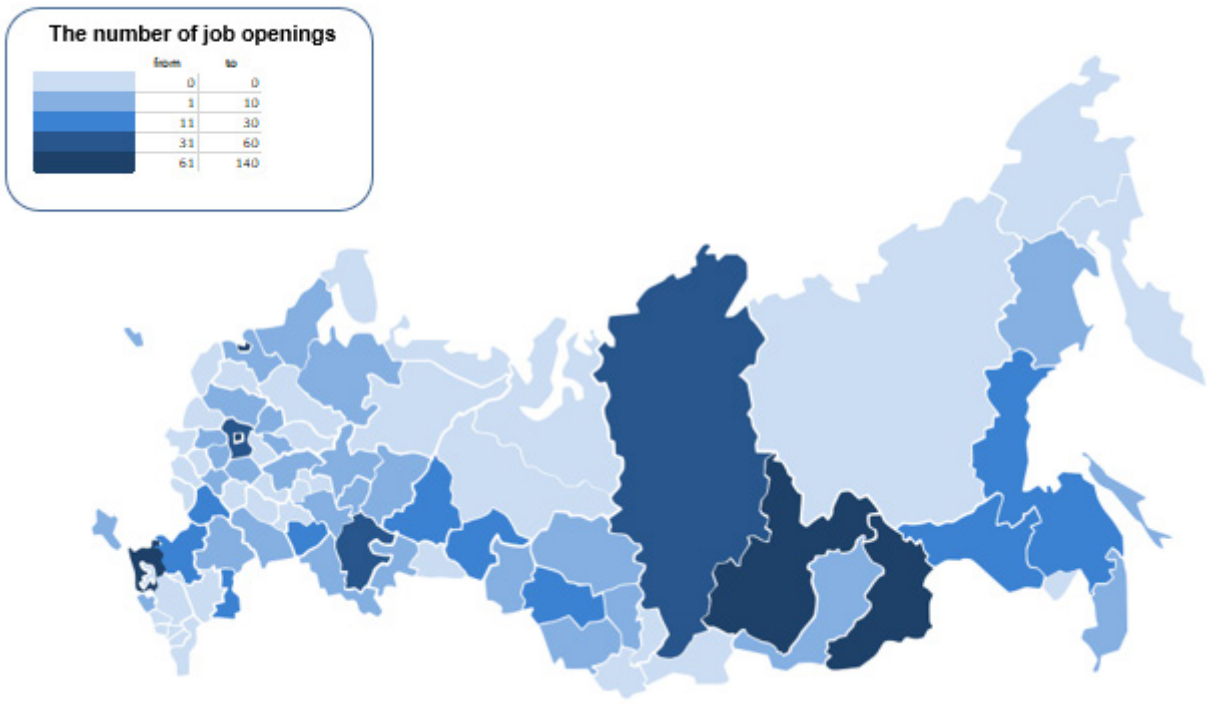

Figure 1. *Heat map of the distribution of the number of vacancies containing the phrase "sustainable development" for April 20, 2023*

Source: compiled by the authors based on statistical data on vacancies based on the results of the vacancy analysis (posted on HeadHunter). Retrieved from: https://hh.ru/search/vacancy?hhtmFrom=main&hhtmFromLabel=vacancy_search_line&search_field=name&search_field=company_name&search_field=description&text=устойчивое+развитие (Date of access 20.04.23)

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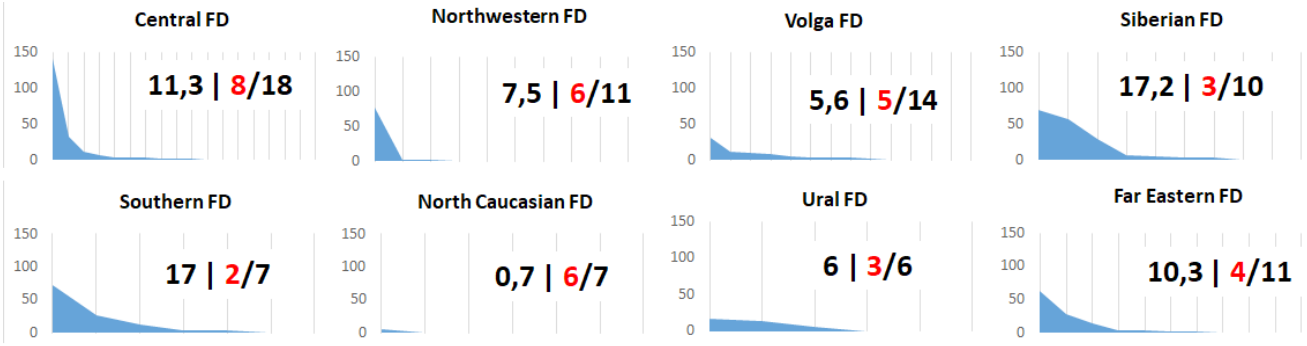

*The x axis represents the regions belonging to the federal district while the y axis, the number of vacancies containing the phrase "sustainable development". The regions are sorted in decreasing order of the number of vacancies

Figure 2. *Distribution of vacancies containing the phrase "sustainable development" for April 20, 2023, by Federal District (AB)*

Source: compiled by the authors based on statistical data on vacancies based on the results of the vacancy analysis (posted on HeadHunter). Retrieved from: https://hh.ru/search/vacancy?hhtmFrom=main&hhtmFromLabel=vacancy_search_line&search_field=name&search_field=company_name&search_field=description&text=устойчивое+развитие (Date of access 20.04.23)

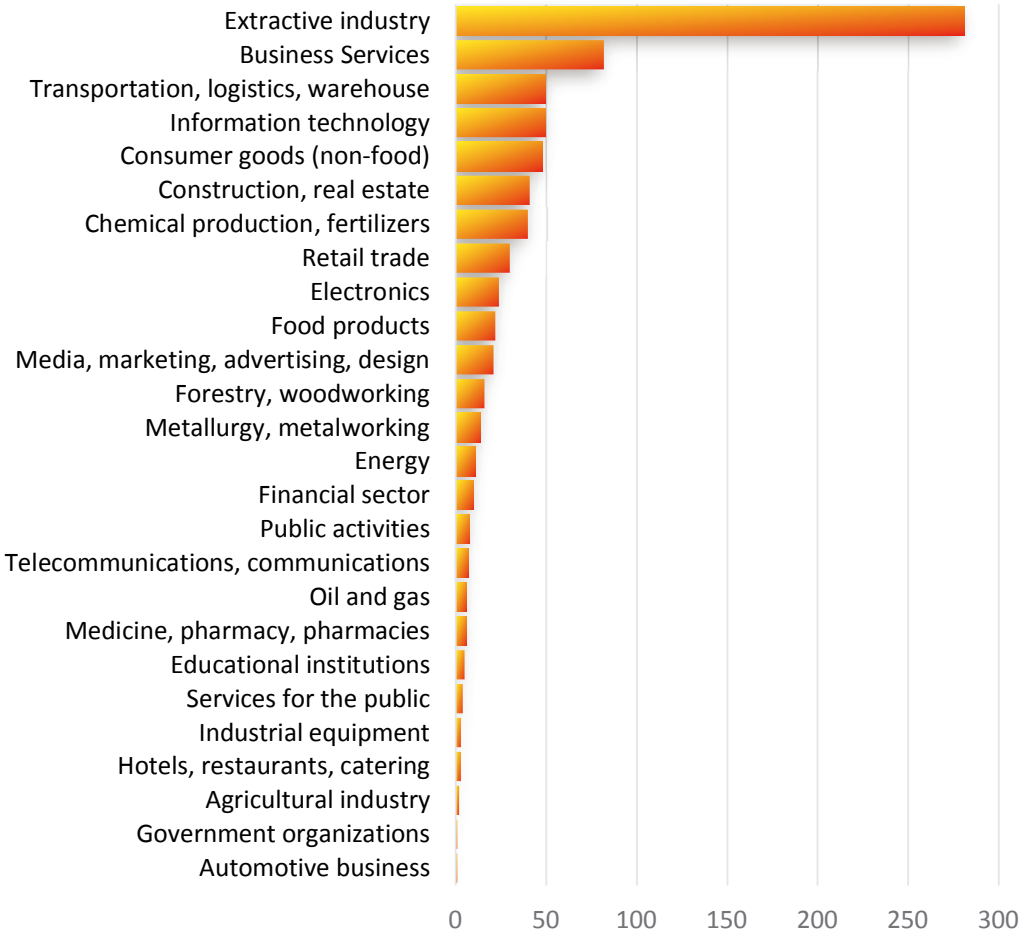

Figure 3. *Distribution of vacancies on the subject of sustainable development by business sectors*

Source: compiled by the authors based on statistical data on vacancies based on the results of the vacancy analysis (posted on HeadHunter). Retrieved from: https://hh.ru/search/vacancy?hhtmFrom=main&hhtmFromLabel=vacancy_search_line&search_field=name&search_field=company_name&search_field=description&text=устойчивое+развитие (Date of access 20.04.23)

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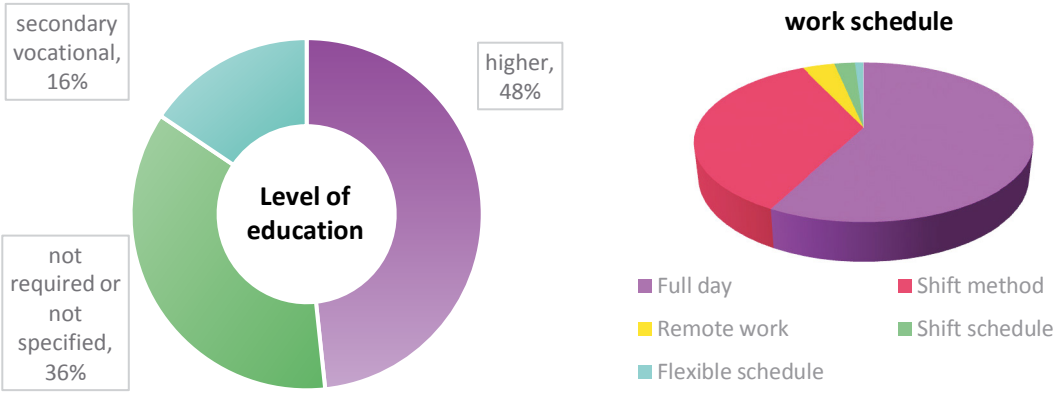

Figure 4. *All-Russian statistics on vacancies containing the phrase "sustainable development"*

Source: compiled by the authors based on statistical data on vacancies based on the results of the vacancy analysis (posted on HeadHunter). Retrieved from: https://hh.ru/search/vacancy?hhtmFrom=main&hhtmFromLabel=vacancy_search_line&search_field=name&search_field=company_name&search_field=description&text=устойчивое+развитие (Date of access 20.04.23)

uation can be explained by the economic lag of the North Caucasus Federal District and the low level of implementation of the principles of sustainable development in it.

It can be noted that employers from regions with completely different economic, demographic, geographical, and climatic conditions are interested in the topic of sustainable development today. Despite the fact that Russian enterprises require enterprises of completely different industries (Fig. 3), the largest number of personnel is required by the extractive industry; in the second place there are companies providing various types of business services, including consulting.

The diagram shows that, at the moment, not all sectors of the economy are in demand for specialists with competencies in the field of sustainable development. The greatest interest in such personnel is shown by enterprises in the industrial sector; this can explain the high proportion of job offers on a shift basis (35% of all offers); nevertheless, more than half of companies are looking for full-time employees (58%); the share of vacancies with the possibility of remote work is about 4% (Fig. 4).

Such a "conservative" working schedule is explained by the specifics of the industry specialization of the companies under study, as well as the specialization of the vacancies they need.

Since the regions of Russia are highly differentiated by climatic and geographical conditions, economic development, and industrial specialization, enterprises of different industries are represented differently in Russian regions, and the requirements for the necessary competencies for specialists in sustainable development will differ. In order to identify the general requirements of employers for the skills of sustainable personnel, it is necessary to consider regions with similar economic conditions. Within the framework of this study, the demand for specialists in the field of sustainable development was studied using the example of the regions of the Southern Federal District. This selection is justified by the close geographical proximity of the regions in the south, shared regional conditions, and the widespread availability of vacancies related to sustainable development in the chosen areas.

Demand for sustainable development specialists in the south of Russia: a view from the labor market

Considering the vital link between the educational services market and the labor market, a more in-depth study was conducted on the characteristics of job openings related to sustainable development posted by companies in the South of Russia. As of April 20, 115 vacancies were identified on the HeadHunter website across six southern regions, accounting for approximately 14% of the nationwide demand. Interestingly, when examining the distribution of demand for personnel focused on "sustainability" in the Southern Russia regions, we found that while it would be logical to expect that more vacancies would be concentrated in larger and economically more developed cities, this was not the case (Fig. 5, Table 2).

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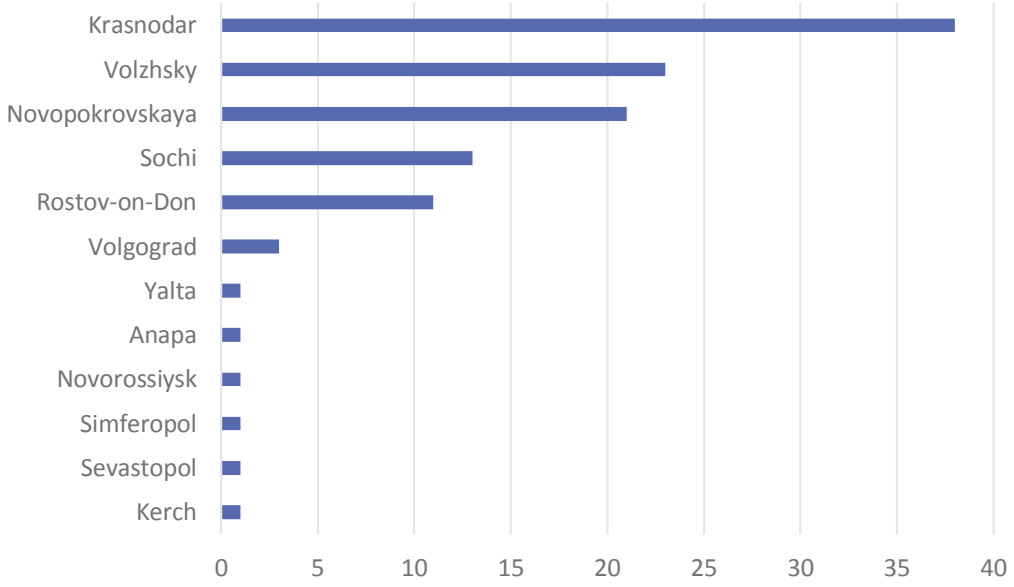

Figure 5. *Structure of distribution of the number of vacancies on sustainable development in southern Russian regions*

Source: compiled by the authors based on statistical data on vacancies based on the results of the vacancy analysis (posted on HeadHunter). Retrieved from: https://hh.ru/search/vacancy?hhtmFrom=main&hhtmFromLabel=vacancy_search_line&search_field=name&search_field=company_name&search_field=description&text=устойчивое+развитие (Date of access 20.04.23)

Table 2

Analysis of the main employers in the south of Russia who have posted vacancies on the HeadHunter website containing the phrase "sustainable development"

Company	Cities of presence	Number of vacancies
AVA Group of Companies	Krasnodar, Sochi, Anapa, Rostov-On-Don	44
JSC Voltair-Prom	Volzhsky	23
GBUZ Novopokrovskaya CRH MZ KK	Novopokrovskaya, Krasnodar	22
ANCOR	Volgograd, Krasnodar, Rostov-On-Don	6
ROWAN LLC	Rostov-On-Don, Volgograd, Krasnodar	6
Home office	Kerch, Yalta, Krasnodar, Rostov-On-Don	4
EXPRESS LLC	Krasnodar	2
MODIS	Krasnodar	1
Asterix LLC	Krasnodar	1
Defense-Rus	Krasnodar	1
Ingka Russia	Rostov-on-Don	1
GC Unitile	Rostov-on-Don	1
GlaBar LLC	Simferopol	1
Hotel Biography	Novorossiysk	1
The First Bit	Sevastopol	1

Source: compiled by the authors based on statistical data on vacancies based on the results of the vacancy analysis (posted on HeadHunter). Retrieved from: https://hh.ru/search/vacancy?hhtmFrom=main&hhtmFromLabel=vacancy_search_line&search_field=name&search_field=company_name&search_field=description&text=устойчивое+развитие (Date of access 20.04.23)

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If we look at the demand for personnel in sustainable development, we will see that the leading position is occupied by Krasnodar, followed by the smaller city of Volzhsky in Volgograd region. Even though its population is under 350 thousand, Volzhsky is among the largest industrial cities in the Lower Volga region. The third position is occupied by the village of Novopokrovskaya, with a population of less than 50 thousand.

This disparity in job opportunities is directly linked to specific enterprises positioning themselves as sustainable. We found that 15 employers fill 115 vacancies across the southern regions of Russia. Notably, the AVA Group of Companies, Voltir-Prom JSC, and Novopokrovskaya CRH of the Ministry of Health of the KK emerge as clear leaders, representing 77% of the demand for stable personnel in the region. For instance, in Novopokrovskaya, the primary employer is "GBUZ Novopokrovskaya CRH MZ KK," involved in the Federal Target Program "Sustainable Development of Rural Areas for 2014–2017 and for the Period until 2020." In Volzhsky, all selected vacancies are from JSC "Voltair-Prom," which is engaged in sustainable tire production and hiring across various specialties, from staff training specialists to pickers and movers.

To understand the essential skills required by enterprises in the south of Russia implementing sustainable development principles, we analyzed the key skills reflected in the vacancy texts of companies (Fig. 6).

As part of the study, key skills were categorized into four main groups:

1) Personal skills: This group encompasses qualities reflecting an individual's character and work discipline. Overall, employers did not prioritize personal qualities significantly, with skills from this group accounting for only 8% of the total. Among these, the most valuable for organizations were result orientation, responsibility, and learning abilities, each observed in four vacancies.

2) Social and managerial skills: This group includes skills associated with management and communication functions. Employers placed particular importance on applicants' ability to work in a team, highlighted in 21 vacancies.

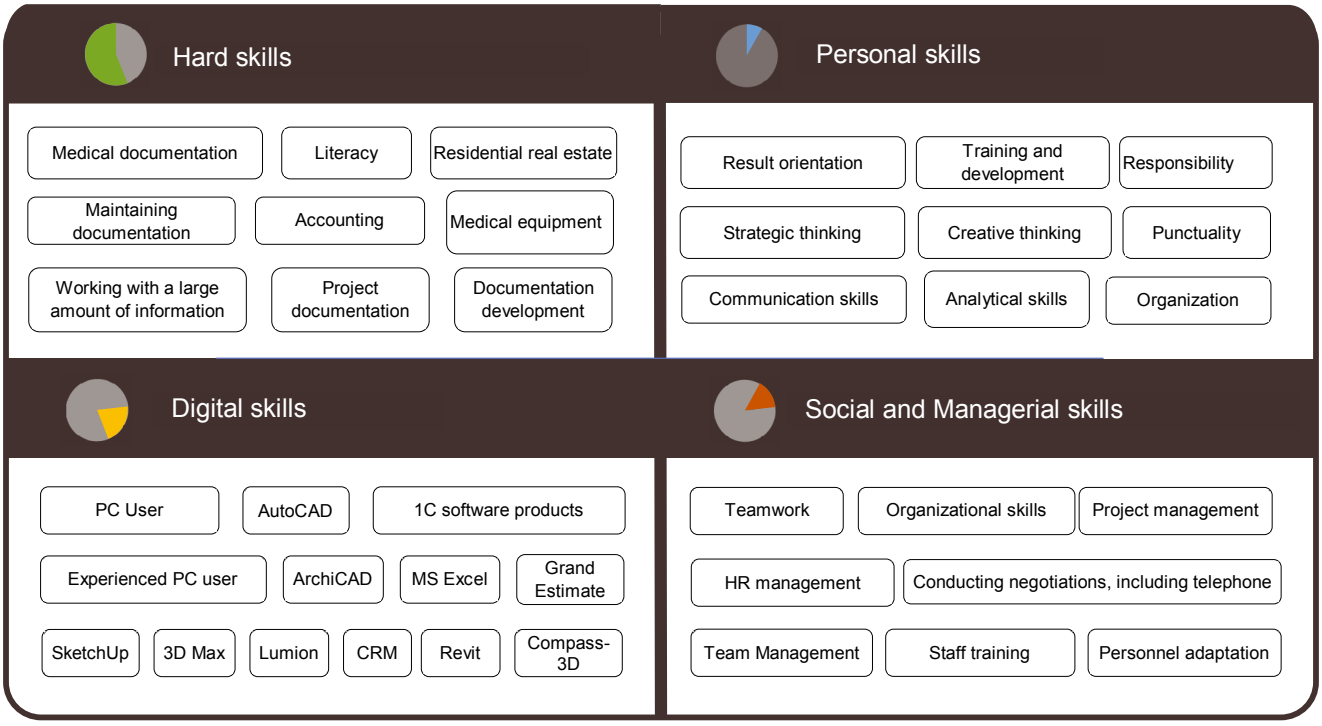

Figure 6. *Structure of the most popular key skills from vacancies on the subject of sustainable development in southern Russian regions*

Source: compiled by the authors based on statistical data on vacancies based on the results of the vacancy analysis (posted on HeadHunter). Retrieved from: https://hh.ru/search/vacancy?hhtmFrom=main&hhtmFromLabel=vacancy_search_line&search_field=name&search_field=company_name&search_field=description&text=устойчивое+развитие (Date of access 20.04.23)

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3) Digital skills: Encompassing knowledge of specific software products and general digital literacy, this group is significant for companies. The crucial aspect of digital literacy, as indicated by skills like "PC user" or "experienced PC user" in 22 vacancies, was particularly emphasized, along with other skills related to the company's specific software.

4) Hard skills: This is the most extensive group, constituting 56% of the total. It encompasses skills directly linked to the technical expertise of the applicant and is the most diverse, featuring 187 distinct skills due to the sample's specificity.

Overall, the featured skills are notably diverse, stemming from the comprehensive sampling across various specialties rather than a specific specialization. The demand for "sustainable" personnel by enterprises is influenced not only by the company's internal strategy and its commitment to sustainable development principles but also by legislative initiatives and restrictions. These external factors often serve as stronger motivators than the personal inclination of the organization's leadership to address environmental and social concerns.

As an illustration of key benchmarks governing sustainable development, we can refer to the metrics outlined in the federal project "Closed-Loop Economy:"

1) The target for the utilization of secondary resources and raw materials from waste across various economic sectors by 2030 is set at 32%, marking a substantial increase from the zero value recorded in 2021;

2) Another goal is to establish eight ecotechnoparks and develop their corresponding infrastructure by 2024. From 2025 to 2030, the focus will shift to the expansion of ecotechnoparks through the establishment of waste recycling facilities and the utilization of secondary raw materials, involving active participation from investors and ecotechnopark residents.

It should be noted that the federal project "Closed-Loop Economy"[10] focuses not only on the creation of sustainable production but also on the organization of sustainable consumption. One of the key indicators reflected in the passport of this project is the annual conduct of advertising, information, and educational campaigns with an annual coverage of the population of at least 10 million people per year. In 2024, this figure is expected to increase to 15 million people, and by 2030, it should reach a value of 30 million.

With this in mind, it can be concluded that in order to build a circular economy, it is necessary to develop skills of various types, and to look for ways to influence value attitudes and behaviors in order to obtain significant results from the production and consumption sides.

It should be noted that almost half of the vacancies were intended for professionals with higher education (Figure 4). This emphasizes the importance of analyzing higher education programs, especially in terms of how they address skills related to sustainability.

Circularization and sustainability skills in the south of Russia: master's degree programs and labor market demand

For the ten universities chosen based on the aforementioned methodology, we conducted an analysis of master's degree programs to identify the incorporation of circular economy skills within them (analyzing skills aligned with educational standards). Figure 7 illustrates the count of master's degree programs offered by the examined universities across different areas (2022 enrollment year) and indicates the number of programs integrating circular skills.

The top three institutions with the highest number of master's degree programs are Don State Technical University, Kuban State University, and Southern Federal University. In terms of the number of programs incorporating circular competencies, the top three universities remain unchanged: Don State Technical University, Southern Federal University, and Kuban State University.

Following an analysis of 1,031 master's degree programs to assess the inclusion of circular economy skills, the proportion of master's programs containing such skills was determined (see Figure 8). The South Russian State Polytechnic University (NPI) had the highest percentage of programs involving circular skills (9 programs out of 52). This can be attributed to the university's focus on technical and technological profile programs, including areas like Technological Machines and Equipment, Automation of Technological Processes and Production, Mechatronics, and Robotics, among others.

[10] Passport of the federal project "Closed-Loop Economy", Municipal Solid Waste magazine, 2022, news.solidwaste.ru retrieved from https://news.solidwaste.ru/wp-content/uploads/2022/07/EZTs_pasport.pdf (Date of access 19.04.23)

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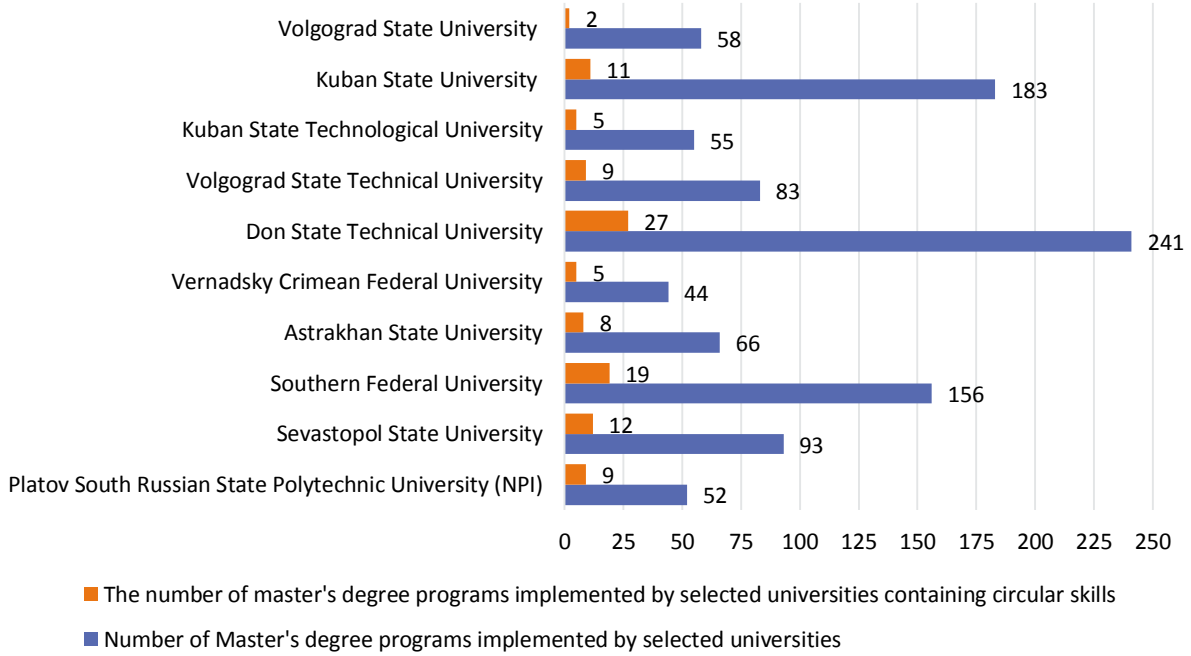

Figure 7. *Number of master's degree programs in selected universities and number of master's degree programs in selected universities containing circular skills (2022 enrollment year), units*

Source: developed by the authors using the data retrieved from: Volgograd State University (https://volsu.ru/), Kuban State University (https://www.kubsu.ru/), Kuban State Technological University (https://kubstu.ru/), Volgograd State Technical University (https://www.vstu.ru/), Don State Technical University (https://donstu.ru/), Vernadsky Crimean Federal University (https://cfuv.ru/), Astrakhan State University (https://asu.edu.ru/), Southern Federal University (https://sfedu.ru/), Sevastopol State University (https://www.sevsu.ru/), Platov South Russian State Polytechnic University (NPI) (https://www.npi-tu.ru/)

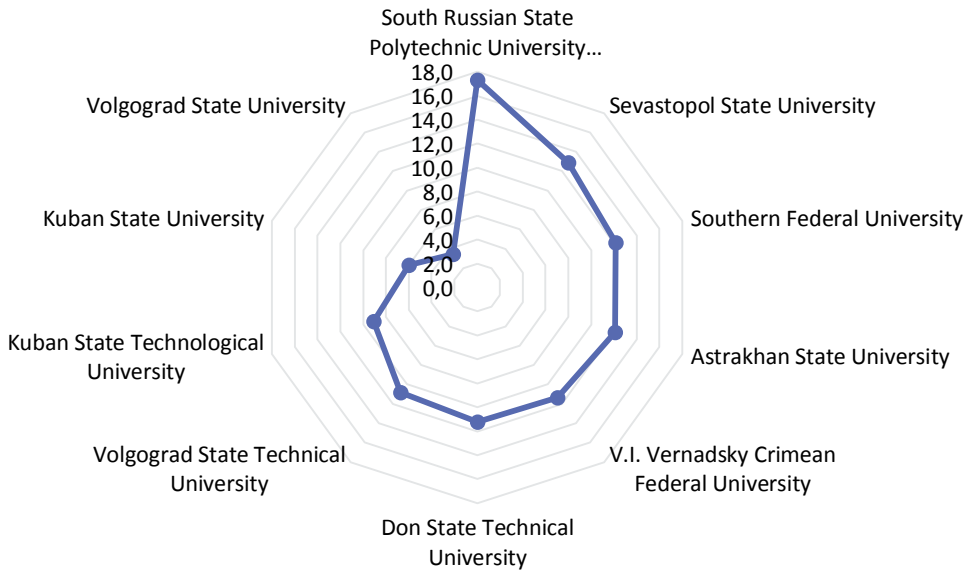

Figure 8. *Proportion of Master's degree programs containing circular skills in the given universities (2022 enrollment programs), %*

Source: developed by the authors using the data Retrieved from: Volgograd State University (https://volsu.ru/), Kuban State University (https://www.kubsu.ru/), Kuban State Technological University (https://kubstu.ru/), Volgograd State Technical University (https://www.vstu.ru/), Don State Technical University (https://donstu.ru/), Vernadsky Crimean Federal University (https://cfuv.ru/), Astrakhan State University (https://asu.edu.ru/), Southern Federal University (https://sfedu.ru/), Sevastopol State University (https://www.sevsu.ru/), Platov South Russian State Polytechnic University (NPI) (https://www.npi-tu.ru/)

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Sevastopol State University, Southern Federal University, and Astrakhan State University have almost the same proportion of educational programs containing circular competencies (12.9%, 12.2%, and 12.1%, respectively).

Sevastopol State University boasts such areas of study as 05.04.06 Ecology and Nature Management, 07.04.04 Urban Planning, 12.04.04 Biotechnical Systems and Technologies; 15.04.04 Automation of Technological Processes and Production; 15.04.06 Mechatronics and Robotics. The Southern Federal University has the following programs: 05.04.01 Geology, 05.04.06 Ecology and Nature Management, 06.04.02 Soil Science, 19.04.01 Biotechnology, 07.04.01 Architecture. Astrakhan State University has the following programs: 04.04.01 Chemistry, 05.04.06 Ecology and Nature Management, 06.04.01 Biology, 06.04.02 Soil Science, 35.04.04 Agronomy, etc.

Competencies aligned with circular economy principles fall within the categories of both general professional skills and specific professional skills. Key competencies include applying practical knowledge of legal foundations related to subsoil use, economics, and geological work while adhering to principles of rational natural resource use and environmental protection. Other competencies involve developing and organizing environmental protection measures, ensuring environmental safety, and documenting reporting in accordance with established requirements.

These competencies extend to studying and assessing the environmental impact of human activities, such as air, water, and noise pollution, soil contamination, climate change, and the depletion and destruction of natural resources. Additionally, individuals possessing these skills can monitor compliance with environmental protection requirements, plan and execute engineering and environmental works, participate in environmental assessments of territories and water areas, and assess technological productions using biological methods for environmental and biological safety.

Numerous other competencies aligned with circular economy principles are integral to this skill set.

Even seemingly unrelated areas of study such as 15.04.04 Automation of technological processes and production, 15.04.06 Mechatronics and robotics, and 06.04.02 Soil Science share competencies aimed at fostering circular economy principles, for example, conducting research for rational land use and protection, organizing production tests for soil fertility management, and developing eco-friendly methods for resource use in mechanical engineering. Overall, master's programs equip students with the knowledge and skills needed for work in a circular economy, providing them with an understanding of its principles, the ability to analyze and optimize resource processes, and to develop and implement innovative technologies. A crucial aspect of circular economy skills involves proficiency in data management, particularly in the context of digitalization and automation, where specialists with these skills can optimize resource processes and develop new business models effectively.

Another skill that is crucial for the circular economy is effective teamwork, given its interdisciplinary nature and the need for collaboration across various economic sectors. Proficient teamwork enables specialists to efficiently tackle complex tasks and innovate within the closed-cycle economy.

Additionally, the ability to analyze risks and make decisions amid uncertainty is important, necessitating the training of specialists to adapt swiftly to changing conditions and formulate new business models. Integrating theoretical knowledge with practical experience, such as engaging in real projects related to the circular economy, is a key approach to developing these skills. Continuous updates to educational programs and teaching methods are equally vital, ensuring that students should have access to the latest information and technologies to thrive in a rapidly evolving economic environment.

Conclusion

Our theoretical analysis reveals a well-developed taxonomy of circular economy skills, indicating their broad typology, diversity, and multi-component nature. However, theoretical constructions lack sufficient grounds for evaluating the practical implementation of these skills and the availability of human capital for transitioning to circular economy models. The proposed methodological approach involves the assessment of the regional labor market demand for circular economy skills and evaluation of the availability of these skills by checking if they are included in master's degree programs at top universities.

Based on empirical findings, we found that there is a demand for circular economy skills

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among employers in Russia, although the picture varies significantly across different regions of the country. A closer examination of southern Russian regions revealed a relatively high demand for workers with these skills while the analysis of master's degree programs at leading universities in these territories indicated that these skills are incorporated into a substantial number of programs.

However, the overall analysis indicates an insufficient alignment between the demand and supply of these relevant skills. To address this, it is advisable to actively involve regional authorities in shaping educational demands presented to universities, as this is essential for generating demand in the job market for the corresponding competencies. In short, universities should play a central role in developing competencies for the labor market. To this end, it is necessary to devise methods and approaches for predicting changes in the job market and proactively training specialists with the required skills. This, in turn, necessitates close collaboration between the education system, science, and the real sector of the economy, aiming to establish a unified ecosystem and formulate methods for both quantitative and qualitative assessment of personnel for the circular economy.

The study's limitations are rooted in its exclusive focus on master's degree programs and the omission of individuals' values and behavioral patterns from the scope of competency analysis.

The priority areas for future research include expanding the analysis beyond master's degree programs and developing tools to balance the supply and demand of circular economy skills in the regional labor market.

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Online ISSN 2412-0731

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ARTICLE INFO: received September 16, 2023; accepted January 25, 2024

ИНФОРМАЦИЯ О СТАТЬЕ: дата поступления 16 сентября 2023 г.; дата принятия к печати 25 января 2024

Online ISSN 2412-0731