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Bruno S. Sergi · Elena G. Popkova · Anna A. Ostrovskaya · Alexander A. Chursin · Yulia V. Ragulina *Editors*

Ecological Footprint of the Modern Economy and the Ways to Reduce It

The Role of Leading Technologies and Responsible Innovations

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Introduction: Opportunities for Advanced Technology and Responsible Innovation in Reducing the Ecological Footprint of Today's Economy

The ecological footprint of the economy embodies the environmental costs of economic growth: the consumption of resources and energy, as well as the production and consumption waste. In the twenty-first century, the economy's ecological footprint has reached a critical level and needs to be significantly reduced to maintain a healthy environment and preserve the natural heritage for future generations. Initiatives to reduce the economy's carbon footprint are being implemented globally as climate change issues are keenly felt worldwide.

Decades of industrialization, recently replaced by Neoindustrialization 4.0, have led to a serious decline in biodiversity. This has caused a surge in zoonotic diseases, emphasizing the need to protect ecosystems. The scale of environmental pollution from waste is so great that species have begun to adapt to their new habitat. Genetic mutations pose risks to public health. Advanced technology and responsible innovation help maintain the achieved economic growth rate while reducing the economy's ecological footprint.

The advanced technology of the digital economy was developing and spreading during the Fourth Industrial Revolution. Advanced technology makes it possible to automate business processes, thereby increasing their environmental friendliness through greater transparency, accountability, and intelligent support for environmental decision-making. Responsible innovations are innovative applications of corporate environmental responsibility, such as environmental management, environmental marketing, ESG investments, green jobs, and green value chains.

First, opportunities for advanced technology and responsible innovation in reducing the ecological footprint of today's economy include improving environmental monitoring. For example, the Internet of Things (IoT) and ubiquitous computing (UC) make it possible to control natural resource consumption accurately.

Green workplaces stimulate environmental innovation, responsibility, and discipline of employees. Environmental taxes and quotas on resource consumption and production waste, including carbon emissions, make optimizing the use of natural resources possible. Green value chains encourage the collective adoption of advanced technology and responsible innovation by all participants.

Second, circular business practices are developed. Digitalization makes it possible to systemically integrate responsible innovations into all stages of the value chain. The reuse of raw materials in recycling makes it possible to reduce the cost of production, strengthening its price competitiveness. The transition to renewable energy supports decarbonization. Clean energy is available. Nevertheless, using clean energy may be associated with additional costs that can be reduced through advanced technology.

Additionally, responsible innovations in marketing and finance help attract green investments and stimulate demand for products with improved environmental properties. Digital marketing helps generate consistently high demand for products produced by circular plants using renewable energy among responsible communities in sustainable territories.

Third, the energy efficiency of production facilities is improved. Advanced technology has improved energy properties. The digital competition supports introducing energy innovations,

making them more attractive to investors. In addition to enhancing digital competitiveness, businesses adopting advanced technologies improve their energy efficiency.

The one-time capital cost of implementing advanced technology provides long-term financial benefits through increased sales and reduced energy costs. Advanced technology also provides enhanced control over energy consumption, preventing leakage and wasteful use of energy resources. In the fuel and energy complex, it helps reduce the risks of environmental disasters due to gas leaks, oil spills, etc.

Fourth, a climate-neutral economy is ensured. Responsible innovation in the area of climate change contributes to the climate adaptation of businesses and the achievement of a carbon-neutral economy. Responsible innovation enables the development of sustainable areas in harmony with ecosystems, particularly in smart regions with automated environmental controls.

Advanced technology and responsible innovation also support the adaptation of industries to climate change and the translation of successful experiences. It is possible to create sectoral environmental clusters, green innovation networks, ecological technoparks, environmental public-private partnership projects, and special economic zones in sustainable areas to conduct environmental R&D jointly, support the creation of green jobs, and introduce climate innovation among their participants.

Fifth, corporate environmental reporting as part of the documentation in the field of sustainable development is improved. Advanced technology makes it possible to automatically collect big data for corporate environmental monitoring and generate corporate sustainability reports based on it. Responsible innovation creates opportunities and incentives to increase the transparency, detail, and openness of this reporting to all stakeholders.

In the information society, digital environmental reporting plays an important role in investment and consumer decisions. Advanced technology also simplifies environmental quality certification and eco-labeling of products. Moreover, responsible innovations make biodegradable product packaging available. This supports the development of environmental culture in responsible communities and the combination of digital and green competition.

This book aims to systemically reflect the issues noted, comprehensively address and accurately measure the ecological footprint of today's economy, and highlight the potential of advanced technology and responsible innovation in reducing it. The scientific novelty of this book and its contribution to the literature lies in the fact that it systemically reflects the environmental properties of advanced technologies and environmental innovations from the perspective of their contribution to reducing the ecological footprint of the economy.

The book's novelty lies in the fact that it discusses in detail the international experience of applying advanced technology and responsible innovation to reduce the economy's ecological footprint. In particular, the book reflects the experience of the BRICS countries, the Eurasian Economic Union (EAEU), Zambia, and Russian regions. This makes the book particularly useful for reducing the ecological footprint of the economies in developing countries, whose experience is the least studied in the existing literature, representing a gap that this book aims to fill.

The practical relevance of the book stems from the fact that it details specific advanced technologies—digital models and digital twins, ensemble algorithms, solar databases, blockchain platforms, data systems for evaluating innovative investment projects, Web 3.0, and responsible innovations in intra-corporate environmental control, e-commerce, digital marketing, and smart government regulation. With this, the book has formed the guiding manual for achieving technological advancement in implementing a green economic growth model.

The book is logically divided into four parts. The first part identifies and measures the ecological footprint of today's economy and identifies key green innovations and ESG practices to reduce it. The second part details responsible innovations in the digital economy and advanced technology to reduce the ecological footprint of today's economy. The third part outlined the institutional framework for responsible innovation in society, business, and government, as well as its contribution to reducing the economy's ecological footprint.

The book concludes with the fourth part, which presents international experience in reducing ecological footprints at the level of regional and national economies, as well as groups of countries.

The book is intended for scholars engaged in studying the issues of innovative development of the economy. Scholars will find a comprehensive scientific look at the possibilities of advanced technology and responsible innovation in reducing the economy's ecological footprint. The green perspective of digitalization presented in the book opens up a wide field for further scientific research.

The book may also be of interest to practicing experts. Business representatives will find ready-to-use application solutions for improving the environmental attributes of products, combating climate change, and implementing corporate environmental responsibility programs based on cutting-edge technology and responsible innovation. For public authorities, the book provides scientific and methodological recommendations for improving state environmental regulation and reducing the ecological footprint of today's economy through stimulating the use of advanced technologies and responsible innovation by business entities.

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Contents

Ecological Footprint of Today's Economy; Green Innovations and ESG Practices to Reduce It

Research of International Standards of Green Economy

Svetlana E. Sobenina, Sergey S. Murtuzaliev, and Svetlana Yu. Murtuzalieva

Abstract

Responsible attitude of a person to the resources of the Earth aims to find a reasonable compromise between the growth of well-being and the preservation of natural resources. Standards of the green economy help achieving green growth. Study examine efficiency of measures taken and challenges to developing the green economy. The research has shown that many agreements between different countries contribute to the popularization of the green economy worldwide. However, some countries are reluctant to change their economy to fit the green standards. United efforts of countries and international organizations should make the transition to a green economy for most economies a painless and profitable experience. Paper concludes that economic development is accompanied by a continuous increase in production and consumption. The potential of the energy sector, primarily renewable electricity, as well as energy conservation and energy efficiency, is huge. International institutions can contribute to developing a green economy by following the principles of unity and consistency.

Keywords

Green economy • Green growth • Carbon emissions • Energy sector • Renewable energy sources • European Green Deal • International organization

JEL Classification

M4 • K8

1 Introduction

Green growth strategies focus on providing a sustainable basis for realizing the potential of natural resources. This potential includes providing critical life-supporting conditions, which is what the green economy considers.

The natural transition of humankind to alternative energy at this stage is impossible without external influence. The key factor that can restrain the growth of hydrocarbon consumption and meet the increasing demand for electricity from renewable sources is the state and supranational impact. By increasing the tax burden on the raw material, the country can launch the process of replacing raw energy. There is a need for a transition to green technologies, the environment will already be irreparably damaged primarily with international organizations such as the WTO, OECD, UN, OSCE, and others.

The difficulty of green transition explains traditional energy sources that are currently more profitable, although they are more toxic than alternative ones. Governments are afraid of declining competitiveness due to the transition to alternative energy sources. The issue of switching to alternative sources has been raised since the founding of the UN, designed to prevent global catastrophes and neutralize the influence of particular countries on the world order to gain an advantage. This causes a dilemma of individual advantage of the country for the preservation of ecology on the planet.

2 Materials and Methods

The agreements adopted by international organizations equally impose obligations and restrictions on the parties to the agreement. Responsibilities are imposed on all parties to the agreement equally, and the benefits of introducing these responsibilities are clear.

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The most significant international agreements that contribute to use of green means and methods in manufacturing industry, transport, and fuel and energy complex are presented in Dzhakupova et al. (2018). A distinctive feature of the UN Framework Convention was the principle of universal responsibility of countries. Convention was adopted but have not reached the post-industrial stage and to strengthen the responsibility of developed countries that have already caused damage to the environment.

3 Results

The successful European "Green Course" laid the foundation for these transformational changes. Primarily, the Commission took measures to promote the growth of the market of cars with zero or minimum emissions into the atmosphere.

The Commission also proposes to charge for carbon emissions for the aviation sector, which has so far been an exception to transport subject to an emissions tax. In addition to the tax, the Commission proposes promoting the use of environmentally friendly aviation fuel, namely, to oblige aircraft to use environmentally friendly mixed fuel for all departures from EU airports.

As for marine sector, it is proposed to extend carbon charges as well. Technologies change value chains in many sectors, especially in energy, transport and construction, contributing to the creation of stable and high-paying jobs across Europe, that might dramatically decrease unemployment rate.

Increased use of renewable energy and the electrification of economy are to contribute to the creations of many jobs in these sectors. Improved energy efficiency and increased use of environmentally friendly fuels might affect many industries what will consequently require more highly qualificated labor force.

Due to the fact that the transition to cleaner energy sources can lead to an increase in production cost, to maintain the competitiveness of products produced by the EU and prevent unfair competition from abroad, it is planned to introduce a carbon tax on the territory of the EU for those companies importing to the EU goods whose countries of origin have less stringent climate rules.

It also proposes a policy which strengthen trade between companies with environmental initiatives by lowering the priority of companies without environmental initiatives in tender procedures.

The next direction of modernization is the repair of buildings. Building repairs are designed to save energy by protecting against extreme heat or cold (EURACTIV.com. 2022). The program includes repairs of residential buildings and public buildings, such as offices or shopping centers. It also should promote the use of renewable fuels in transport industry.

To reduce harmful emissions and lower energy costs it is necessary to reduce energy consumption. The transition to a green economy also implies a change in the tax system, namely the provision of legal incentives for a "green transition" (European Commission, n.d.). Thus, according to the project, it is planned to reduce tax rates on heating and transport services to mitigate the social consequences of switching to alternative energy sources.

4 Discussion

To determine which international organizations have expertise in a particular sector, consider the number of programs used by organizations in some sectors. Figure 1 shows the number of programs implemented by the organization within the sector, regardless of the number of regions in which it is implemented. UNEP implements almost 70% of all general economic programs. The programs implemented by this organization are aimed at preserving biodiversity and developing cooperation between countries.

According to Fig. 1, it can also be seen that each industry is regulated by several international organizations at once. The least regulated sectors of the economy are tourism and education. Currently, only one project is being implemented in the educational sphere, and two projects are being implemented in the tourism sector.

The target sector for green economy development programs is the energy sector. Currently, 21 programs are focused on it. Approximately 45% of them are implemented by UNECE. The remaining programs implemented in the energy sector are almost evenly distributed among the five organizations. Half of all energy sector programs are implemented not on the scale of a single country but in the entire region at once, in particular in the Caucasus, Eastern Europe, and Central Asia.

Many programs implemented in the energy sector directly affect the energy sector. The most widespread and rapidly developing types of "green" energy are currently the following:

- Hydropower is based on the most widely used type of renewable energy, which accounts for 54% of all generating capacities in the world operating on these sources. China is currently the leader in the production of hydroelectric power;
- Wind energy production. New composite materials technological advances have contributed to increasing the service life and reducing the cost of wind turbines. As a

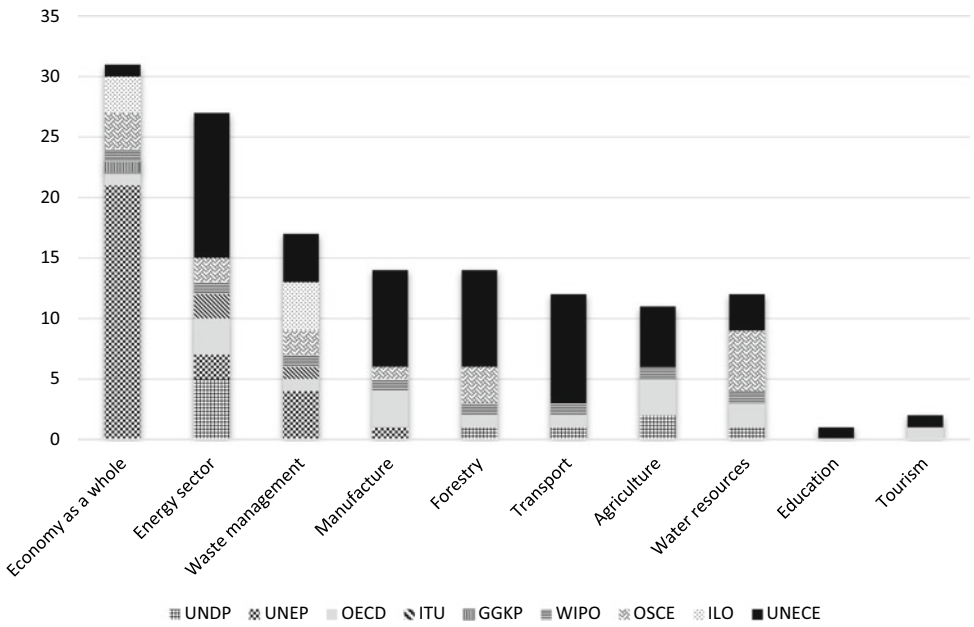

Fig. 1 Number of programs implemented by international organizations in some sectors, 2017. *Source* Compiled by the authors based on OECD (2017)

result, for example, onshore wind power generates about 10% of all energy in the UK and is the most economical alternative energy option for it. Offshore wind farms supply electricity to about 4.5 million households in this country;

- Solar energy is the fastest-growing type of green energy. United Arab Emirates produce electricity in an amount sufficient to reduce the carbon footprint equivalent to the effect of eliminating 200 thousand cars;
- Bioenergy is the fourth largest type of "green" energy. It is based on traditional biomass sources innovative use, such as agricultural by-products and household waste. China, the UK, and India are the current leaders in bioenergy production. Brazil, Germany, the USA, and Sweden are also actively developing these technologies;
- Geothermal energy. Iceland is the largest producer of geothermal electricity in the world. Notable positions in this area are occupied by Indonesia, Italy, Mexico, the Philippines, and the USA (Earth ORG 2021).

The main trends of the green economy in 2022 are as follows:

(1) Activation of developments in the field of green hydrogen. Green hydrogen is a fuel obtained by the electrolysis of water. The transition to this fuel type makes it possible to provide the most environmentally friendly energy production chain. However, the technologies of hydrogen extraction and storage have not yet been fully developed, and their significant disadvantage is the great need for clean fresh water. The products are very expensive (from $4 to $6 per kg). Although, as technology improves, the competitiveness of environmentally friendly hydrogen increases in cost. Australia, Chile, the European Union, Germany, Japan, Saudi Arabia, and the USA have already committed to making significant investments in its production (Columbia Climate School 2021). The growing interest in "green" hydrogen as opposed to traditional energy raises the question of the feasibility of using an extensive gas infrastructure. For example, according to Bloomberg, switching to hydrogen fuel may make American gas pipelines with a total length of three million miles (or 4.8 million km) unnecessary. The new US administration is already demonstrating a critical attitude towards large pipeline construction projects. Hydrogen technologies also threaten the interests of Gazprom, the largest supplier of natural gas in the EU. Some companies are already thinking about organizing the production of hydrogen and ammonia next to wind farms (Eurostat 2022);

(2) Improvement of advanced bioenergy technologies using organic waste from landfills and reservoirs, agricultural waste, etc. as an energy source. Heat, liquid, or gaseous biofuels (ethanol, biogas, biodiesel, etc.) are obtained through thermochemical or biochemical reactions of biomass processing. Due to the expansion of the scale of such industries, emissions of the third category of harmfulness are reduced (US Environmental Protection Agency (EPA) 2022);

(3) Increasing interest in geothermal energy, which can become the most reliable renewable energy. At a depth below the freezing level of the soil (two to three meters from the ground surface), the temperature remains

constant throughout the year and is approximately equal to the average annual outdoor temperature. This can be used as an energy source to generate electricity or heat, heating or cooling the building. It is considered to be one of the most efficient energy sources.

Nevertheless, traditional (fossil) energy sources currently play a dominant role in the global energy balance and individual countries. Fossil fuels can be easily transported from one country to another. This market is highly profitable. On the contrary, the cost of more environmentally friendly (or alternative) energy sources is falling due to large-scale investments in innovative technologies (Pichai 2018).

However, it is unlikely that the green energy wave will displace all oil and gas producers in the coming years. A certain decline in demand for fossil energy resources in the 2020 "COVID" year is the result of force majeure, and it is incorrect to consider it as a trend. Moreover, the pandemic unexpectedly showed the world community a probable future without hydrocarbons—without flights on airplanes and trips by car. As it turned out, humanity cannot live without oil and gas yet.

According to the OPEC World Oil Outlook report published in 2021, the oil will remain the main fuel in the global energy balance until 2045. By 2025, against the global economic recovery after the coronavirus pandemic, this figure may grow to 31%. As of 2020, the share of RES was 2.5% of the total energy balance. By 2045, it can increase up to 10%. The demand for oil over the same period will increase by 12% (Katkov 2021).

5 Conclusion

Economic development is accompanied by a continuous increase in production and consumption. The potential of the energy sector, primarily renewable electricity, as well as energy conservation and energy efficiency, is huge.

International institutions can contribute to developing a green economy by following the principles of unity and consistency. In world practice, there are a large number of instruments and institutions that distribute resources and create projects for sustainable environmental development. Therefore, it is important for states to plan the implementation of green projects according to the cost of implementation in financial, labor, and other resources and green projects of other countries.

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Investment Cooperation Between the EU and the EAEU Countries in Building a "Green Economy" (Case of the EBRD's Activities in Armenia)

Ludmila L. Razumnova and Natalia P. Savina

Abstract

The research focuses on the activities of the European Bank for Reconstruction and Development (EBRD) on the territory of Armenia as one of the member countries of the Eurasian Economic Union Integration Association (EAEU). The research aims to identify trends and features in the field of financing green economy projects and their impact on the country's energy potential and sustainable development. The research is based on the analysis of the EBRD database, a comparison of expert opinions, and current data on the implementation of funded projects. In particular, it is revealed that many projects are implemented with the involvement of funds from third international financial organizations, integrated into broader national development programs of relevant industries and sectors, etc. There is sufficient evidence that in recent years, cooperation between the EBRD and Armenia has increasingly focused on supporting projects aimed at maintaining sustainable development, including such areas as urban and industrial infrastructure, energy conservation, renewable energy, etc. It is revealed that the EBRD's financing contributes to the accelerated modernization of energy companies' capacities, creating incentives for the introduction of renewable energy sources, improving the efficiency of resource use, decarbonization, and maintaining the financial stability of national companies.

Keywords

EBRD • EU • EAEU • Armenia • Green economy • Energy efficiency • RES • Decarbonization

JEL Classification

F15 • F34 • Q42 • P48

1 Introduction

The European Bank for Reconstruction and Development (EBRD) was one of the first international and regional financial institutions (between IMF, the World Bank Group, the Inter-American Development Bank, the African Development Bank, and the Nordic Investment Bank) to focus their efforts on increasing energy efficiency. Back in 1994, the EBRD established specialized energy efficiency divisions. The EBRD has been implementing the Sustainable Energy Initiative (SEI) since 2006. Between 2006–2012, the EBRD invested approximately 11 billion euros under the SEI in more than 620 projects, which accounted for 20%–30% of the bank's total operations. Simultaneously, Russia accounted for the largest share of funding—22%, while the countries of Eastern Europe and the Caucasus—21%, South-Eastern Europe—20%, and Central Europe and the Baltic States—17% (Evdokimov 2013, p. 133).

To create additional tools for improving the efficiency of financing, in 2016, the Bank's Board of Directors launched the Concept of Green Economy Transition (CGET), which provides for an investment increase in environmental protection up to 40% of the total amount of EBRD funding by 2020 (Bondarenko et al. 2019). It involves expanding existing activities aimed at supporting energy efficiency and renewable energy projects, financing sustainable energy, and introducing innovations in environmental finance and software products (Tanaka 2020). One of the mechanisms for introducing innovative climate technologies is the activity of the Finance and Technology Transfer Center for Climate Change (FINTECC). Currently, of all the EAEU countries, the activity of the FINTECC includes only cooperation with Kazakhstan.

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Nowadays, the EBRD has become a leader in climate change financing. It plans to become a majority green bank by 2025. The response of the EBRD to COVID-19 remains to help countries achieve green, inclusive, and sustainable economic recovery. From the end of 2022, all investment activities of the EBRD will be consistent with the goals and commitments of the bank's partner countries adopted under the Paris Climate Agreement.

Armenia's energy sector is characterized by a shortage of its own energy resources and small electricity production at existing nuclear and hydroelectric power plants, making it highly dependent on Russian energy supplies. The planned launch of the single EAEU electricity market by 2025 can significantly increase electricity consumption in Armenia. It is estimated that between 2018–2040, the demand may increase by 50%–74% while the capacity of hydropower and renewable energy will grow slightly—by 0.1 GW and 0.3 GW, respectively; gas demand will increase by 28.5–35.2% depending on the possibility of purchasing gas at Russian prices. Oil products demand will grow by 7–17% (EBRD 2021a, b, c, d).

In this context, it is apparent that Armenia is facing an acute problem of increasing the use of its own resource potential efficiency for energy production. It is also interesting to study the experience of its cooperation with the EBRD in the field of financing green technologies from the point of view of implementing joint sustainable industrial projects.

2 Materials and Method

The research was conducted based on the official information provided by different websites, including the International Energy Agency (IEA), the EBRD, and the Eurasian Economic Commission, as well as Russian and foreign secondary sources presented in open-access information and analytical sites, specialized scientific journals, and expert opinions of Armenian business representatives. The analysis of the collected information was carried out from the point of view of the implementation of EBRD's financing mechanisms within the framework of the Concept of Green Economy Transition (Bondarenko et al. 2019) using the methods of systematization and grouping of data and comparison of expert opinions and generalization.

According to the studies conducted by I. A. Bondarenko and others on the EBRD's activities in the EAEU countries, including Russia, Belarus, Kazakhstan, Armenia, and Kyrgyzstan, in 2015–2016, the bank implemented a large number of projects in green economy, energy saving, corporate governance quality, and road infrastructure within the Strategic and Capital Framework 2016–2020, which showed the expansion of the scope of traditional banking activities and interest in global institutional projects (Bondarenko et al. 2019). In all the EAEU countries, the EBRD provided loans in three main areas:

- Improving economic sustainability.
- Regional and global economy.
- Solving global and regional problems, including combating climate change and improving energy security.

In 2021, the largest number of active projects in the EAEU in terms of both quantity and volume of financing was implemented in Kazakhstan—128 projects worth 2648 million euros. Russia implemented 65 projects worth 1035 million euros, of which 25% are in the field of sustainable infrastructure construction. As for the other countries, Belarus implemented 67 projects worth 930 million euros, Kyrgyzstan—67 projects worth 150 million euros, and Armenia—58 projects worth 400 million euros (EBRD 2021c).

According to the IEA, Armenia's energy demand exceeds 3 million tons of oil equivalent. In 2019, it amounted to about 3.40 million tons of oil equivalent. Natural gas dominates the energy balance—63%; renewable energy accounts for 8.8%. Although Armenia does not produce fossil fuels, it covers 24% of its energy needs from domestic production, mainly from nuclear and hydropower. The structure of electricity production by the source is more diversified. In 2019, it was also dominated by natural gas (40%). A smaller share accounted for hydroelectric power (31%) and nuclear power (29%). In the Caucasus region, Armenia is the only country producing nuclear power (IEA 2021; Statistical Committee of the Republic of Armeni 2022).

As a member of the EAEU, Armenia participates in the building of a common energy market (oil, gas, electricity, etc.), which was created under the unique conditions, especially in relation to the electricity market and the maintenance of national energy security (Gibadullin and Bortalevich 2016; Vinokurov 2008). Its creation will provide the participating countries with an increase in internal network capacity and optimize the utilization of generating capacity (Baykov 2012; Sopilko 2019).

Armenia should build a strategy for the electric power industry development primarily based on its own sources (construction of small and medium-sized hydroelectric power plants, RES, and nuclear power plants), as well as by increasing gas supplies from Iran. Simultaneously, Armenia is aware that there will be risks of disruptions in the energy resources supply from Russia and Iran in the future. Moreover, there may be risks associated with the operation of an outdated nuclear reactor and monopoly energy suppliers, as well as difficulties in implementing market reforms (Sopilko

et al. 2020). In this context, the market development of renewable energy sources, including wind and solar energy, and the transition to energy saving technologies by means of external and internal financing are essential for the Armenian economy.

3 Results

According to the analysis of the EBRD's projects, cooperation between the EU and Armenia in the field of green energy is one of the most successful areas of its investment activities in the EAEU countries. The bank is a leading institutional investor in the country. It made the promotion of energy efficiency one of its main activities. Since the beginning of its work in Armenia in 1992 and until 2019, the EBRD has invested 1.36 billion euros. About 90% of the investments are made in the private sector (EBRD 2021; Seldon.News 2019).

Between 2015 and 2021 the EBRD implemented 200 projects in Armenia with total investments amounting to 1,887 million euros, of which 1,146 million euros are total disbursements, 83% of which have been invested in the private sector. Currently, the number of active projects is 59 worth of 415 million euros. Operating assets amount to 2.98 million euros, with equity accounting for 17% of the portfolio. The portfolio composition is characterized by the largest share of sustainable infrastructure projects (46%); 44% are in the financial sector, and 10% are in the industry, trade, and agribusiness (EBRD 2021a).

As can be seen from Table 1, the number of projects in the field of infrastructure and energy development has increased significantly over the past five years. Thus, only in the first half of 2021, out of seven projects in this area, five projects financed with the participation of private Armswissbank and ACBA bank relate to the support programs of green economy and small and medium-sized enterprises (SMEs) development. One loan was issued in the transport sector ("VISP—Armenian Air Navigation") and one in the energy sector ("GrCF2 W2-ENA Investment Program"). Among all these projects, only one, in the field of navigation, is a loan provided to the state. The remaining loans are provided to private companies.

Among the projects of the EBRD that are being implemented on the territory of Armenia between 2017–2021 (Table 1), we will highlight the following four projects in the field of green economy:

- Modernization of the "Electric Networks of Armenia" (2017)—"ENA-Modernization of Distribution Network."
- Construction of the Masrik-1 Solar Power Plant (2019)—"Masrik-1 Solar Power Plant."
- Participation in the bonds of the Zangezur copper-molybdenum plant (2019)—"ZCMC Bond Participation."
- EBRD loan under the Green Economy Financing Program (GEFF) with the participation of ACBA Bank and ACBA Leasing (2021)—"GCF GEFF Regional —GEFF Armenia-ACBA Bank."

3.1 "ENA—Modernization of Distribution Network" (2017)

The project "ENA—Modernization of Distribution Network" is a loan of $80 million for the modernization of Armenia's outdated energy infrastructure, including the reconstruction and modernization of lines and substations, replacement of outdated equipment, expansion of the automated electricity metering system and connection of new users, installation of a new automatic control system, etc. As a result of its implementation, the company managed to reduce electricity losses from 13.5 to 6.8–6.9%, including by improving the efficiency of the personnel remuneration system. The completion of the second phase of the program (a loan approved in September 2021 by the EBRD and the Asian Development Bank in the amount of $105 million) will digitalize the distribution network and the efficiency of electricity use and improve the reliability of power supply. The company's ten-year modernization program worth $726 million will be completed by 2027 (Avanesov 2021).

3.2 "Masrik-1 Solar Power Plant" (2019)

"Masrik-1 Solar Power Plant" project will receive a long-term loan in the amount of up to $35.4 million from the EBRD, the International Finance Corporation (IFC), and the European Union Neighborhood Investment Platform (NIP) for the construction of the Masrik-1 photovoltaic power plant with a capacity of 55 MW (Gegharkunik province). The construction of Masrik-1 is being carried out by the consortium Photowatio Renewable Ventures B.V. from the Netherlands with Spanish roots and the Spanish company FSL Solar SL. In 2024, the solar power plant will be put into operation and will start supplying electricity to more than 20 thousand homes, with a conditional reduction in carbon dioxide emissions of more than 40,000 tons per year.

By 2030, Armenia plans to build more large and small solar power stations, including Aig-1, with a capacity of 200 MW for $174 million, which will be built by Masdar company from the UAE. It has the necessary experience in 40 countries worldwide. It is also planned to construct Aig—2 (Kotayk province). As part of the renewable energy

Table 1 EBRD projects in Armenia, 2017–2021

	Date	Project name	Sector	Public/ private	Status
1.	May 18, 2017	ENA—Modernization of Distribution Network	Energy	Private	Repaying
2.	May 17, 2019	Masrik-1 Solar Power Plant	Energy	Private	Disbursing
3.	August 16, 2019	Meghri BCP Modernization	Transport	Public	Signed
4.	November 14, 2019	ZCMC Bond Participation	Natural resources	Private	Signed
5.	January 20, 2020	Converse Bank MSME Loan	Financial institutions	Private	Disbursing
6.	January 20, 2020	Converse Bank WiB Loan	Financial institutions	Private	Disbursing
7.	February 17, 2020	GrCF2 W2—Yerevan Bus Project	Municipal and environmental infrastructure	State	Signed
8.	May 13, 2020	RF—ENA Resilience Loan	Energy	Private	Complete
9.	May 18, 2020	RF—InecoBank	Financial institutions	Private	Complete
10.	July 23, 2020	Resilience Framework: ACBA bank	Financial institutions	Private	Repaying
11.	December 22, 2020	GCF GEFF Regional—GEFF Armenia II—Inecobank	Financial institutions	Private	Disbursing
12.	April 30, 2021	FIF—ACBA SME Competitiveness Loan	Financial institutions	Private	Disbursing
13.	April 30, 2021	GCF GEFF Regional—GEFF Armenia—ACBA Bank	Financial institutions	Private	Disbursing
14.	June 11, 2021	GrCF2 W2—ENA Investment Program	Energy	Private	Disbursing
15.	June 11, 2021	VISP—Armenian Air Navigation	Transport	State	Concept Reviewed
16.	June 29, 2021	FIF—EaP SMEC —InecoBank	Financial institutions	Private	Signed
17.	June 30, 2021	FIF—EaP SMEC—ArmSwissBank	Financial institutions	Private	Disbursing
18.	June 30, 2021	GCF GEFF Regional—GEFF Armenia—Armswissbank	Financial institutions	Private	Disbursing
19.	November 8, 2021	FIF —EaP SMEC—Armeconombank	Financial institutions	Private	Approved
20.	December 14, 2021	FIF—Ameriabank SME Loan	Financial institutions	Private	In exploratory, pending final review
21.	December 14, 2021	FIF—EaP SMEC—Ameriabank	Financial institutions	Private	In exploratory, pending final review
22.	December 14, 2021	FIF—EaP WiB—Ameriabank WiB loan II	Financial institutions	Private	In exploratory, pending final review

Source Compiled by the authors based on the EBRD Armenia data (EBRD 2021a)

development program, they expect to build solar power plants with a capacity of up to 110 MW in various regions of Armenia. In two surveyed areas, Spanish company Aries Engineering and Systems presented feasibility studies for constructing solar power stations (Masrik-2 project). Small solar power plants and autonomous power stations will also be built. By 2025, the total capacity of solar power plants in the country may reach about 500 MW, or more than 10% of the country's electricity generation capacity; it will increase to 1000 MW by 2030 (ROSATOM Western Europe 2021).

Armenia also has favorable conditions for wind farms, as wind speed is 8.5 m per second. The first networked wind farm with a capacity of 2.64 MW was built in 2005 at the expense of an Iranian grant. By 2040, wind capacity may increase to 500 MW. Armenia aims to meet 26% of domestic demand from renewable energy sources by 2025 (ROSATOM Western Europe 2021).

3.3 "ZCMC Bond Participation" (2019)

"The ZCMC Bond Participation" project involves the EBRD's participation in securing $11 million bonds of the Zangezur Copper-Molybdenum Combine (ZCMC). It aims to improve energy efficiency and reduce CO_2 emissions. This project provides additional liquidity in the debt capital market of the largest Armenian mining company, which operates the greatest copper-molybdenum mine in the South

Caucasus region. The company's shareholders are officially German Cronimet Mining (60%), Yerevan Pure Iron Plant OJSC (15%), Armenian Molybdenum Production LLC (12.5%), and Zangezur LLC Mining (12.5%) (Kulaev 2021). A secondary effect of the project is the replacement of diesel trucks with electric ones, which leads to a reduction in greenhouse gas emissions (EBRD 2019).

3.4 "GCF GEFF Regional—GEFF Armenia—ACBA Bank" (2021)

"The GCF GEFF Regional—GEFF Armenia—ACBA Bank" project involves providing a loan to one of the largest private banks in Armenia, ACBA bank, in the amount of up to $5 million within the framework of the GCF GEFF Regional Structure in Armenia: 75%—will come from EBRD and 25%—from the Green Climate Fund (GCF) for investing in technologies and services to climate change mitigation and adaptation, with a particular focus on promoting renewable energy, energy efficiency, and climate-resilient technologies (solar photovoltaic, solar thermal, geothermal heat pumps, and biogas technologies) (EBRD 2021b).

Nowadays, the GEFF program is represented in 26 countries worldwide, where it cooperates with 140 local financial institutions. The investment portfolio of the program is 4 billion euros. A special feature of the program is that the owners of businesses and photovoltaic power plants can return up to 20% after plants construction (AMI Armenian News 2019).

4 Conclusion

Currently, the issues of choosing a strategy for building a low-carbon economy and prospects for decarbonizing economic sectors and creating favorable conditions for building a green economy are on the agenda of all the EAEU countries. However, these countries are heterogeneous in terms of the structure of energy balance and the level of energy consumption, which leads to the fact that national development strategies differ significantly and cannot have fully coordinated goals (Eurasian Economic Commission 2021).

The example of Armenia shows that this country, which does not have large hydrocarbon reserves, has better conditions for building a green economy than other EAEU countries. An analysis of the EBRD's projects implemented in Armenia reveals general trends in external financing processes:

- More and more projects are green investments that involve increasing the company's social responsibility and respect for natural resources.
- Many projects are implemented by means of funds from three international financial organizations and are integrated into broader government programs.
- The projects are mostly medium-term. Nevertheless, they are implemented within the framework of stable and long-term cooperation between the EBRD and its Armenian partners and can be extended.
- The lending of the EBRD contributes to the development of capital markets, liquid funds, and public financing, thereby supporting the sustainable development of the financial system.
- Some projects have been negatively affected by the political instability characteristic of Armenia in recent years.

Without developing a national energy security doctrine that ensures the achievement of national interests in the domestic and foreign markets, the introduction of green technologies will not be able to guarantee a balanced and sustainable energy consumption system. Therefore, we should strive to ensure that the national strategies of all members of the EAEU are based on common principles that support maximum efficiency of functioning of individual national energy markets. More active work in this area is necessary in connection with the need for effective recovery of economic growth during the pandemic and with the growing influence of green transformation of the leading countries of the world, including the EU Green Deal, on third countries.

According to Tigran Avinyan, Deputy Chairman of the Annual Meeting of the EBRD Board of Governors, the EBRD has played a prominent role in building knowledge and capacity to design and implement reforms, promote structural change, and create a more favorable investment climate (EBRD 2021d).

Simultaneously, the developing energy crisis in Europe has shown that the energy transition plan implemented in the EU by phasing out hydrocarbons is chaotic, contains many uncertainties and risks (regarding the structure and volume of investment in mining, the growth rate of transition to RES, ongoing institutional policies, etc.) and can develop according to an unpredictable scenario (Razumnova 2021). It follows that strategies for achieving carbon neutrality developed by the most advanced countries and organizations may lose all meaning without active international cooperation in this area.

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Data Mining Efficiency in the ESG Indexes Verbalization Analysis (on the Example of the MSCI Site)

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Abstract

The authors consider the efficiency of the data mining method for analyzing the verbalization specifics of the ESG indexes on the example of business documentation and correspondence of MSCI Inc. as one of the best-known global suppliers of ESG and climate products. The relevance of the research is due to its interdisciplinarity and testing of new methods for large text corpora analysis. Text mining implies methods for obtaining new information from the flow of texts or large text data and involves compilation, organization, and analysis of large collections of documents to extract the necessary information and detect previously unknown links between texts. A three-step automatic selection to determine the most widespread lexical patterns when analyzing the verbalization of the ESG indexes demonstrates that these steps, namely text segmentation, *n*-gram detection, and category labeling, are related to each other. The scientific novelty of this research is determined by the flexibility of the proposed analysis model because it can be used as an open-source tool, i.e., the approach presented herein can be extended to many other types of texts and languages.

Keywords

ESG indexes • Data mining • Verbalization • *N*-gram • Bag of words

JEL Classification

C15 • C45 • C61 • Q01 • Q51

1 Introduction

Nowadays, science is definitely aimed at some streamlined arrangement of the accumulated over the past centuries knowledge that invariably pushes many researchers to look for new methods of analysis within the framework of various concepts and paradigms. As for text analysis, linguistics has traditionally been attracted by the search for a variety of morphological, syntactic, stylistic, semantic, pragmatic, and other characteristics by means of various tools, theoretical justifications, argumentation, generalizations, functional areas, etc. Text mining, as one of the new methods, is a rather complex process involving the search for new textual features by automatically extracting information from various written resources.

We are currently witnessing rapid technology development that results from the increase in the information capacity, which most certainly requires new methods of automated and intelligent data processing, as well as new ways to find out and identify implicit patterns. In this regard, it seems essential to improve the reliability of systems and the flexibility of their response to non-obvious changes. However, in the entire array of data, a human can extract only a minor part of useful data. Therefore, data mining as a method of scientific investigation can increase the amount of knowledge gained and help reveal implicit patterns.

Data mining is the process of discovering previously unknown, non-trivial, practically useful, and interpretable knowledge in raw data that is necessary to make decisions in various human activities. The essence of this method is to identify implicit, objective, and useful patterns in a large array of data (Frawley et al. 1992).

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Data mining is not a technology; it is rather a process of finding patterns, deviations, relationships, and trends based on mathematical and statistical algorithms. It is used to solve several tasks, including recognition, classification, or diagnosis of a situation, a phenomenon, an object, or a process with the justification of the decisions taken; predicting situations, phenomena, processes, or states in accordance with the dynamic data samples; running a cluster analysis and data structure research; identifying essential features and descriptions; finding empirical patterns of various types; construction of the analytical descriptions of sets of objects; finding non-standard or critical cases, and reference images descriptions formation.

Several works are devoted to the intelligent text analysis and automatic classification and clustering methods development, most of which are based on a vector model of knowledge representation and on the use of semantic networks, including the works by Deerwester et al. (1990) and Landauer (2003) on indexing by latent semantic analysis, U. M. Fayyad and G. Piatetsky-Shapiro on knowledge discovery in databases (Dai et al. 2004; Fayyad et al. 1996), Salton (1989) on the knowledge representation vector model, Djellali (2013) on text clustering models, and Miller and Fellbaum (1991) on the semantic database. The specific features and perspectives of data mining concepts and techniques are studied in the research by Abrukov et al. (2013), Ball (2013), Berzal and Matín (2002), Boire (2014), Esfahani et al. (2019), Sumathy and Chidambaram (2013), and others.

Research into the use of machine learning is now growing rapidly. Text classification algorithms based on traditional methods do not provide sufficient analysis of semantic and lexicographic relationships of terms. Thus, data mining is extremely efficient and relevant in various scientific fields, including linguistics, because it opens up apparent prospects in the search for new tools and methods of discourse analysis.

2 Materials and Method

The research aims to prove the efficiency of data mining in analyzing large arrays of text data on ESG topics. We tried to identify specifics of the ESG indexes verbalization in the business documentation and correspondence of MSCI Inc. as one of the best-known global suppliers in stocks, bonds, real estate indices, multi-asset portfolio analysis tools, and ESG and climate products. With this purpose, the authors compiled a corpus of texts from the MSCI site of 80,000 words and analyzed the verbal representation of environmental, social, and corporate governance aspects by means of text data mining.

Before building a model and using machine learning algorithms, it is necessary to present the text corpus as a feature vector. A commonly used model in natural language processing is the bag of words (BOW) model. First, a collection of all different words is created, where each word is assigned a value (starting from 0). Then the dictionary can be used to construct d-dimensional feature vectors for individual documents, where the dimension is equal to the number of different words in the dictionary ($d = |V|$). After constructing a vector model of words, we need to extract *n*-grams.

In the *n*-gram model, a token can be defined as a sequence of n-elements. Given a sequence of $n - 1$ words, the *n*-gram model predicts the most likely word that can follow this sequence. When $n = 1$, the probability of the word *wi* appearing in the *i*th position does not depend on the previous words, and the sentence is a sequence of independent words. When $n = 2$, the probability of the word *wi* appearing in the *i*th position is associated only with the previous word $wi - 1$, etc. The *n*-gram model is constructed by calculating how often word sequences occur in a corpus of texts, and then estimating probabilities. The *n*-gram is supposed to be evaluated using TF-IDF. Total frequency (TF) is the *n*-gram frequency coefficient or unit weight in the text, expressing the importance of the word in the text, IDF is the inverse frequency coefficient or unit weight in neutral texts. A weight is assigned to each *n*-gram using TF-IDF. Next to distributing the *n*-grams by weights, it is supposed to find a list of keywords that verbalize ESG indexes.

After preprocessing the text corpus, we analyzed it in Python using the *scikit-learn*, *pandas*, and *nltk* libraries for subsequent text classification. We used the "*k-nearest neighbors*" method. Nearest neighbor classifiers determine the k-nearest neighbors of the test point and calculate the number of points belonging to each class. The class with the largest number of points is considered relevant. To calculate the nearest neighbors, the distance from the new data point to all other training data points is used. The number of nearest neighbors (κ) is supposed to be established by trying different values of κ on the training data. As a result, the value of κ will be used, at which the highest accuracy is achieved on the training data. To implement the method, the KNeighborsClassifier from the scikit-learn Python library was used.

3 Results

The main objective of this research is to prove the efficiency of data mining in the ESG indexes verbalization analysis. The solution to the task required using new methods and approaches mentioned above. We have identified several key characteristics of the experimental texts. The data was preprocessed with the use of the regular expressions package available in Python, then only alphanumeric characters (TF-IDF, Word2Vec, etc.) were saved from them.

Table 1 The most frequently used words in the categories "environment," "social," and "governance"

"Environment"	Emissions/emission	312
	Sustainability/sustainable/sustained	256
	Climate	200
	Green/greenhouse	191
	Global/globally	165
	Carbon	149
	Environment/environmental/environmentally	143
"Social"	Rating	719
	Information	311
	Disclosure	302
	Risk	234
	Question	178
	Opinion	145
"Governance"	Invest/investable/investment/investor	569
	Company	321
	Finance/financed/financial/financing	305
	Market	190
	Regulation/regulations/regulatory	159
	Standard	144
	Management/manager	142

Source Compiled by the authors

The text corpus was built up by means of BoW—sentences were represented by the appearance or absence of a word in a given sentence. First, a corpus of words was formed containing all the words used; the appearance of the word was marked as 1, and the absence of the word was marked as 0. Thus, we identified the most frequent words from the three basic categories "Environment," "Social," and "Governance" (Table 1).

Visualization of the obtained quantitative results allowed us to establish that the language units involved in the verbalization of the ESG indexes in the text corpus for the category "Environment" are in lower priority positions compared to the categories "Social" and "Governance." Besides, the number of lexical units included in the semantic category of "Social" equals to similar indicators of "Governance." The visualization results are shown in Fig. 1.

As we have already noted, TF-IDF and BoW are based on words. The *N*-gram is a solution for BoW, for ignoring a sequence of words, predicting the next word, and typos. Bigrams, trigrams, and *N*-grams are continuous sequences of tokens. Table 2 shows the most frequent sequences of *N*-grams found as a result of the text corpus analysis made in Python nltk.

Next, we organized the obtained results in the most frequent sequences of *N*-grams in the corpus in the form of a spider diagram, which allowed us to visualize the estimated level of their recurrence. The results of the visualization are performed in Fig. 2.

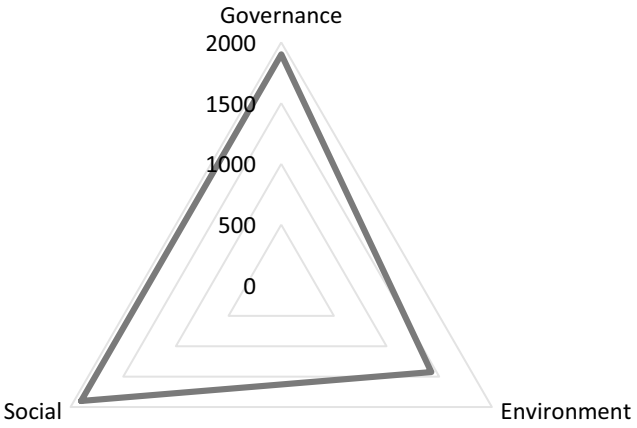

Fig. 1 Spider diagram of the most frequent sequences of *N*-grams in the corpus. *Source* Calculated and built by the authors

Table 2 The most frequent sequences of *N*-grams in the corpus

'Disclosure,' 'requirements'	81
'Climate,' 'related'	71
'Rating,' 'providers'	60
'Risks,' 'opportunities'	59
'Exposure,' 'draft'	59
'Credit,' 'ratings'	56
'Credit,' 'rating'	44
'Climate,' 'change'	43
'Related,' 'risks'	41
'Climate,' 'impact'	41
'Factors,' 'credit'	40
'Products,' 'services'	37
'Scope,' 'emissions'	36
'Benchmark,' 'administrator'	35
'Climate,' 'related,' 'risks'	35
'Environmental,' 'social'	34
'Climate,' 'change'	34
'Green,' 'bond'	33
'Impact,' 'sector'	32
'Rating,' 'provider'	32
'Factors,' 'credit,' 'ratings'	32
'Financial,' 'products'	31

Source Compiled by the authors

At this stage, it becomes obvious that the *N*-grams of the semantic category "Governance" are quantitatively superior to the indicators of the categories "Social" and "Environment."

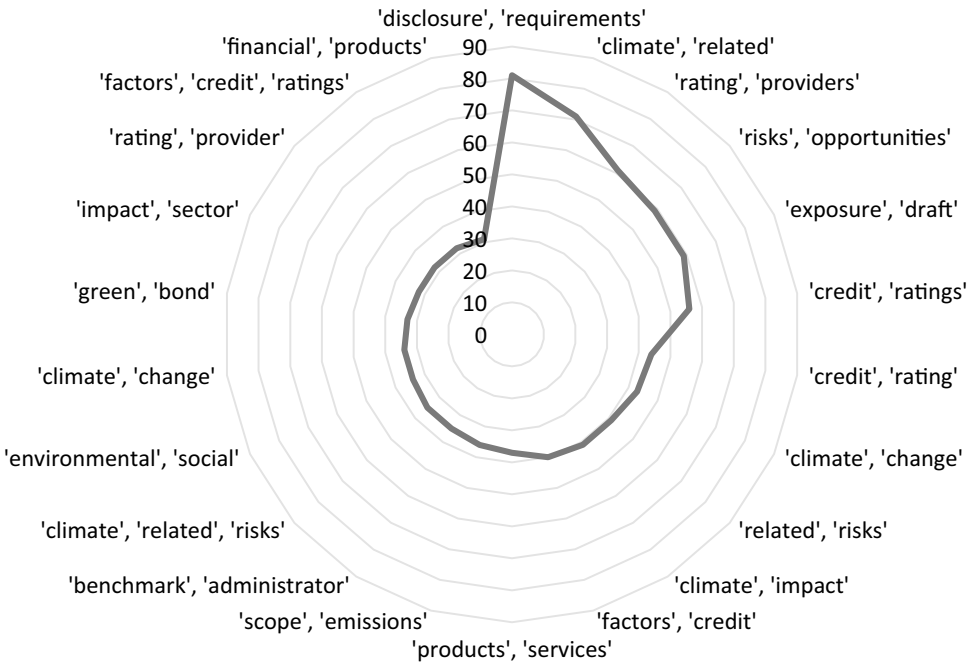

Fig. 2 Spider diagram of the most frequent sequences of *N*-grams in the corpus. *Source* Calculated and built by the authors

4 Conclusion

In this paper, we have presented research on how text corpora data mining can contribute to linguistics. We employed a three-step automatic selection to determine the most widespread lexical patterns when analyzing the verbalization of the ESG indexes. The results demonstrate that these steps, namely text segmentation, *n*-gram detection, and category labeling, are related to each other.

The present study concludes that the ESG indexes in the semantic preference were verbalized within three semantic categories, namely: "Governance," "Social," and "Environment." The result also indicated that the category node had several collocation words that were strongly associated with a particular meaning.

In conclusion, we feel that the application of computational resources to the text corpora analysis will have a profound effect on the direction of linguistic research.

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