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# ADAPTING INTERNATIONAL LEGAL FRAMEWORKS FOR SCIENCE TO THE ARMENIAN CONTEXT: OPPORTUNITIES AND LIMITATIONS

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**Abstract:** This article examines the legislative and legal regulation of science, drawing on the experience of various countries to identify effective models. It analyzes the scientific legislation of several states with advanced research systems and provides comparative assessments. In the contemporary world, no country can develop without adapting to global transformations. Science and the practical application of its results play a crucial role in national development and in improving living standards, which necessitates the internationalization of scientific activity. Therefore, the legal framework must create favorable conditions for scientific progress, innovation, and responses to emerging national challenges.

The current legislation regulating the scientific sphere in Armenia does not adequately address the requirements of 21st-century science, including international cooperation, open science, digitalization, advanced research management, artificial intelligence, and high-technology integration. The purpose of this study is to examine international legislative practices and propose improvements to Armenia's legal framework governing science. Comparative and descriptive research methods were used, relying on scientific literature and normative legal acts.

Based on the legislative experience of different countries, the article recommends incorporating legal definitions of "scientific work" and "scientific result" into Armenian law, adopting flexible evaluation mechanisms for scientific organizations and researchers, and implementing policies that encourage the inflow and retention of scientists. The legislative examples of China and Korea are particularly noteworthy, as they promote the activities of both domestic and foreign researchers and offer broad opportunities for international students. Ultimately, the value of science lies in the effective application of its results, contributing to the prosperity of the country and its people.

**Keywords:** Scientific and scientific-technical activities, legislative and legal regulation, scientist, scientific worker, science law, international scientific and technical cooperation

## Introduction

Science and the state's scientific policy can establish universally accepted relationships in the world grounded in national dignity, equality, solidarity, and mutual responsibility. Science within the state must become a true productive force. This is significant against the backdrop of

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current developments in the Republic of Armenia's foreign policy and security, which further emphasize the importance of increasing the socio-economic role of science and innovation, as well as scientific and technological activity. Naturally, the legal field in the country for those engaged in scientific-technological and innovation activities plays an essential role, directly impacting the attractiveness and effectiveness of such activities, as well as the pace of implementing innovative measures. The legal and regulatory field must create the most favorable conditions for the development of science and innovation activities, relevant to solving the problems facing the state. The legislative field regulating Armenia's scientific sphere does not address 21st-century scientific developments, requirements, international cooperation, or trends in scientific-technological progress. This refers to open science, digitization, international research management models, the application of artificial intelligence, and the integration of high technologies. A clear model of state governance, supervision, and accountability is also not proposed by the legislation currently in force in the Republic of Armenia in the field of science. On the other hand, no country in our time can develop without taking into account the changes occurring worldwide; science and its results, as important factors in ensuring the country's development and raising people's living standards, need to be internationalized. The relevance of this article's theme is conditioned by the aforementioned. The main objective of the study is to propose ways of improvement for the legislation regulating the field in the Republic of Armenia by presenting the experience of legal and regulatory arrangements for science in various countries. For that purpose, the legal and regulatory frameworks in the Republic of Armenia and other countries, make comparisons and correlations, and identify opportunities to localize foreign experience in our country.

#### Literature Review

Russian scientific works related to the legal and regulatory arrangements of science are notable for the depth of problem discussion: V.N. Gordey's "State-legal regulation of the field of science in Russia under conditions of market economy establishment"(2005), L.G. Berlyavsky's "Legal policy of the Soviet state in the field of regulating scientific activity: 1917-late 1920s" (2009), V.P. Baranov's "Methods and tools for improving mechanisms of state regulation of the field of science in the Russian Federation"(2012), E.K. Nechaev's "Legal regulation of scientific research and technological development in regional integration organizations: examples of the European Union and the Eurasian Economic Union"(2017). There are many works devoted to the problem of legal regulation of scientists' status: O.Yu. Osipov's "Social status of young scientists in the region"(2011), S.M. Nikiforov's "Legal entities of public law in Russia in the XVII-XIX centuries"(2017), L.Yu. Chernomorsky's "Trends in changing values of scientific activity in Russia: Youth position" (2005). V.V. Lapaev, A.V. Gabov, L.N. Berg, N.V. Putilo, D.V. Griбанov and others have also addressed issues of normative-legal regulation of scientific activity in their works [1]. There is also a view that the current legal situation of legal and regulatory arrangements for science in the Russian Federation "testifies to contradictory trends in state regulation of the scientific-educational field: it is sometimes rigid, sometimes mild"[2]. D.V. Murzin revealed other shortcomings in the legal regulation of scientific activity and its results related to the legal nature of these results, the status of subjects, forms of scientific activity, contractual foundations of this activity, service results of scientific activity, which testifies to the incomplete legal regulation of science [3].

Each form of legal regulation of science entails risks. The dispositive method can commercialize science. While this brings science into the real economy, it may also introduce inadequate market criteria to evaluate scientific work. The imperative method can slow scientific activity, its financing, and state support. Some Russian scientists discuss whether science law exists as a complex branch of Russian law [4].

Scientific activity, according to economics doctor and professor Pletnev, is activity directed toward obtaining previously unknown knowledge, whose result is not material but intellectual production [5]. Doctor of philosophical sciences and professor Semyonov has also tried to reveal the concept of "science" by presenting it as "a special field or form of intellectual production connected with the generation, verification, and systematization of objective knowledge about reality"[6]. In any case, as some authors claim the principle of freedom of scientific research is oriented towards the general idea of scientific and technological progress—to act as a resource for universal development [7].

In our conviction, the inseparability of three components and their logical continuity are important here: the process of generating objective knowledge about reality continues with the process of converting them into technology, then creating technologies, which implies closely connected means and methods of activity.

American legal literature is not characterized by theoretical discourse on the goals, methods, and functions of legal regulation of scientific activity. As a rule, it comes down to discussion around predetermining the boundaries of the scientist's scientific freedom. These scientific discussions, in turn, are predetermined by the rapid development of genetic engineering, contemporary biotechnologies, and other cutting-edge technologies, whose development principles inevitably clash with existing ethical and humanitarian principles. "Academic freedom must be protected not only morally, but also legislatively. No matter how traditional it may be, without legal guarantees, it is unprotected"[8].

The following well-known figures have addressed the scientific-educational environment as a subject of legislative regulation: A.A. Bolonkin, J.Yu. Stiglitz, M. Friedman, F.G. Cumbs, V. Potter, R. Schmidt, R. Fisher, A. Wildavsky, R.V. Wassmer, A.B. Krueger, J. Grant, K.I. Murray and others. However, in fairness, it should be noted that these authors' works are primarily related to the educational system. Gina M. Hilton, Yadvinder Bhuller's and others' opinion on the legislative regulation of science "A challenge for regulatory authorities is that many governing laws reflect the scientific paradigm of the mid-20th century" [9].

## Methodology

In the scope of the study, we used comparative and descriptive research methods. To analyze the legal and regulatory arrangements in the science field, we examined legislative frameworks of the Republic of Armenia, other countries, and various unions. Scientific works, normative legal acts, statistical data, and reports formed the article's informational basis.

## Analysis

"Scientific cooperations" have a special character. First, engaging in science is a creative activity that does not tolerate external interference and implies the researcher's independence and the probability of obtaining or not obtaining a scientific result. Therefore, the creative process of acquiring new knowledge should not be subject to legal regulation. Second, one of the participants in scientific cooperations is the scientist, the researcher collective, or the scientific

staff, without whom conducting scientific research is impossible. Third, scientific cooperation is regulated by other branches of law (administrative, civil, labor, budgetary, tax, international, etc.). Lawmaking is a creative process whose purpose is to create favorable conditions for the development and vital activity of society. Krasnyansky wrote: "During law-making activity, the legislator not only reflects the diversity of social relationships in their static and semantic aspects but also evaluates them." A robot is not capable of evaluating the legal situation of any problem; instead, this is done by the serving programmer, who in turn is instructed by someone.

According to the Republic of Armenia Law "On Scientific and Scientific-Technical Activity" (RA Law-119, dated 26.12.2000), science, as an exceptionally important factor in economic development, ensuring the country's security, education, culture, and social progress, is under state patronage. The law regulates the relationships among subjects of scientific and scientific-technical activity, state bodies, and users of scientific results, and defines the principles of forming and implementing state policy in the field of science and scientific-technical activity. To develop science as an economic activity, the Republic of Armenia's tax legislation provides a number of privileges. Thus, pursuant to subparagraph 3) of point 2 of Article 64 of the RA Tax Code, scientific research and experimental development work that meets the criteria established by the government is exempt from VAT. A peculiarity of expense accounting for profit tax calculation is established by subparagraph 4 of point 2 of Article 121 of the RA Tax Code; according to subparagraph 2) of point 2 of Article 123 of the RA Tax Code, an additional reduction is provided only for wages and equivalent payments to persons included in the list of professional work in the field of high technologies established by the government, included in the list of activity types in the field of high technologies, by 200%. In addition, pursuant to subparagraph 1.1 of Article 150 of the RA Tax Code, a double low tax rate of 10% is established for income tax on wages and other equivalent payments paid to personnel engaged in occupations included in the list of professional work in the field of high technologies, subject to a specific procedure. According to Article 230 of the RA Tax Code, agricultural institutions and forestry scientific organizations, as well as breeding and seed experimental organizations, are exempt from real estate tax by 50% if the property is used exclusively for scientific purposes [10]. The ideological core of the Strategy updated by Decree N145 of the President of the Russian Federation dated 28.02.2024 is scientific-technical sovereignty. Russian science is defined as "the basis for developing state sovereignty," its role is to create necessary, balanced, and effective decisions aimed at solving social, economic, cultural, and other problems facing the Russian Federation, ensuring the country's security. Special attention is paid to the value and worldview foundation of scientific-technical development, patriotic education of Russian scientists, and their responsibility for achieving great accomplishments. According to the strategy, solving problems aimed at having a high level of Russian science that ensures the necessary quality and pace of socio-economic development requires maximum use of available resources, stimulating scientific progress, in other words, essentially forming a legal regime, preventing emerging risks, neutralizing the influence of factors hindering the development of the scientific-technical process. In the Russian Federation, state policy is oriented toward applying advanced experience in managing the scientific field, with great attention paid to developing the normative base of scientific activity, particularly the following legal acts are in force: Federal Law N127-FZ "On Science and State Scientific-Technical Policy" dated 23.08.1996, Federal Law N70-FZ "On the Status of Science City of the Russian Federation" dated 07.04.1999, Federal Law N139-FZ "On Russian Nanotechnology Corporation" dated 19.07.2007, Federal Law N284-FZ "On Transfer of

Property Rights to Unique Technologies" dated 25.12.2008, Federal Law N316-FZ "On Patent Attorneys" dated 30.12.2008, Federal Law N273-FZ "On Education in the Russian Federation" dated 29.12.2012, Decree N899 of the President of the Russian Federation dated 07.07.2011 "On Approval of Priority Directions of Science, Technology and Technology Development in the Russian Federation and the List of Critical Technologies in the Russian Federation," Decree of the President of the Russian Federation dated 01.12.2016 "On the Strategy of Scientific-Technological Development of the Russian Federation," and others. D.V. Murzin, comparing the Russian Federation Federal Law "On Science and State Scientific-Technical Policy" with UNESCO's "Guarantee on Standardization of International Statistics in the Field of Science and Technology," noted that in the latter, the concepts "scientific research and experimental development" and "scientific research activity" are classified in the field of creative activity, while in Russia they are not. He also emphasized that the lack of emphasis on the creative nature of scientific activity in Russian legislation contradicts social realities and contemporary ideas about science, since "the development of science occurs through surpassing achieved results" [11]. Yu.V. Stepanenko considered the shortcoming of Russian legislation regulating science to be the legal status of state scientific centers: particularly, the provision about the state scientific center is not properly recorded, and no acceptable legislative definition is given. According to him, the legislator also failed to clearly distinguish between "scientific(research) activity" and "scientific-technical activity" [12]. In another work, Yu.V. Stepanenko criticized the definition of the concept "scientific worker," according to which, first, the legislator did not include it in the list of basic concepts; second, the concepts "scientific worker" and "researcher" were equated. It is obvious that any scientific worker is a researcher, but the reverse cannot be claimed. "A researcher is any citizen who engages in research not officially but by personal interest" [12]. It is characteristic that in UNESCO acts, scientific-technical activity is a broader concept than scientific activity and includes scientific activity, experimental development, scientific-technical education, and scientific-technical service. In Russian Federation law, conversely, scientific-technical activity is a component of scientific activity [13]. In the Republic of Armenia, scientific and scientific-technical activities are equated, interpreted as intellectual creative activity directed toward expanding acquired knowledge, obtaining and applying new knowledge. According to the legislation in force in Belarus [14], scientific activity is considered an inseparable component of educational activity regardless of the level of education (preschool, general secondary, professional-technical, secondary professional, higher education), with the scientific-methodological provision of education being consolidated as based on fundamental results of scientific research. According to the Law N273-FZ "On Education in the Russian Federation" of December 29, 2012, the role of science in the educational process has a different interpretation; the main emphasis here is primarily placed on training scientific and scientific-pedagogical personnel, intellectual and creative competitions conducted to increase students' interest in scientific activity. According to Article 1 of the Law "On Scientific Activity" of the Republic of Belarus, "scientific activity is directed toward obtaining new knowledge about nature, man, society, artificially created objects and developing new methods for their application." According to this law, obtaining new scientific knowledge is possible through conducting fundamental and applied scientific research. Besides the mentioned, this law also attributes state scientific-technical and scientific expertise, training and attestation of highly qualified scientific personnel to scientific activity. Here it should be noted that state scientific-technical and scientific expertise

as scientific activity does not raise doubt, which cannot be said about the training and attestation of scientific and scientific-technical personnel.

Within the framework of the CIS union, model laws "On Scientific and Scientific-Technical Activity" and "On the Status of Scientist and Scientific Worker" (at the plenary session of November 25, 2008) were adopted regarding the field of science. Besides this, scientific-technical cooperation between CIS member states is regulated by the following legal acts:

- Agreement on cooperation in interstate exchange of scientific-technical information, which was also adopted to create a common scientific-technological platform between CIS member states, develop national scientific-technical information systems, and implement joint programs [15].
- Interstate program of innovation cooperation of CIS member states until 2030, whose goals are creating conditions for establishing interstate cooperation and increasing the competitiveness of states [16].

The Collegium of the Eurasian Economic Commission on June 24, 2022, approved Recommendation N26 "On Prospective Forecasts and Priorities of Scientific-Technical Development of the Eurasian Economic Union" [17]. The legislative consolidation of scientists' status is also important. This problem is not new in jurisprudence. For example, V.S. Kamenkov notes that the state and society must be oriented: can a person who does not have special professional training and does not master special techniques, methods, and skills of research activity be called a scientist [18]. Although the Inter-Parliamentary Union of CIS member states adopted the model law "On the Status of Scientists and Scientific Workers" as early as 2008, neither in the Russian Federation, nor in the Republic of Belarus, nor in the Republic of Armenia is the scientist's status yet clarified. According to it, a scientist is a physical person (citizen, foreign citizen, or stateless person) who has a scientific degree and/or scientific title, implements professional scientific or scientific-technical activity, and is recognized by the scientific community for the results of their scientific-technical activity. In the Republic of Kazakhstan, the Law "On Science" N407 IV dated 18.02.2011 consolidates the concept of scientist: it is a physical person who conducts scientific research or obtains results from scientific and scientific-technical activity [19]. As follows from this definition, no qualification requirements are presented to these persons. Many aspects of innovation activity are regulated in the Republic of Kazakhstan's Law "On Science," but the definition of principles for the emergence of ownership over intellectual work results financed from the state budget remains outside the regulation framework. In our opinion, solving this problem will eliminate obstacles in the process of implementing innovations in the real sector of the economy. In international practice, it is accepted to receive the results of scientific and scientific-technical processes as intellectual property. Thus, the data collection and research group within the framework of the Organization for Economic Cooperation and Development (OECD) defined the scientific and scientific-technical process as creative periodic activity aimed at increasing knowledge, as well as applying existing knowledge under new conditions. Moreover, this activity must correspond to a number of mandatory conditions: the presence of scientific novelty, uncertainty of scientific activity results (incurred expenses may not coincide with obtained results), creative nature (based on objectively new ideas and principles), periodicity (detailed planning of the entire process of activity, including intermediate and final results), reproducibility (possibility of using and transferring obtained knowledge) [20].

In the legal field of India's scientific activity, a five-year plan methodology is applied, which includes planning state policy in this field. India's scientific-technical system is represented by the following super-agencies: Central government scientific-technical departments, independent research institutes, private research centers, non-governmental organization research centers, state scientific-technical divisions, central socio-economic and other ministries [21]. Central government scientific-technical departments include the Ministry of Science and Technology, the Department of Atomic Energy (founded in 1954), the Department of Biotechnology, the Ministry of Earth Sciences, the Indian Council of Scientific-Industrial Research, defense research and development organizations, and the space department. It is characteristic that 90% of researchers of Indian origin work outside the country, despite the fact that the country's traditional legal culture promotes the development of science and scientific-technical activity. India actively participates in the Shanghai Cooperation Organization; it is a member of BRICS (Brazil-Russia-India-China-South Africa) and RIC (Russia-India-China) [21].

One of the foundations of China's economic miracle is the rapid development of science and the practical application of its results. According to the People's Republic of China's basic law "On Scientific-Technical Progress," one of the goals of legal regulation of science is promoting international scientific-technical cooperation. According to Article 15 of this law, the government of the People's Republic of China cooperates with governments of other countries and international organizations in the field of scientific-technical activity, and also encourages international cooperation and exchange of scientists and technicians from scientific research and technological institutes, higher educational institutions, and scientific-technical public organizations. Article 54 of the aforementioned law clearly regulates the tasks of the state and scientific institutions, as well as the directions of support for researchers invited from abroad and for scientists returning to their homeland. Scientific institutions are obliged to create necessary living and working conditions for Chinese scientists returning to their homeland from abroad, while the state provides permanent residence rights to foreign scientists who come to China for scientific purposes.

The following characteristics are distinguished by analyzing the history of science development in the USA and the foundations of legal regulation:

- Applied orientation of science to the detriment of fundamental science development, which was conditioned by the American desire to make an instantaneous transition from early modernism to mature postmodernism.
- Science develops according to the principle of synergy between higher education, the state, and private business. Dialogue between science, the state, and business promotes the development of various models of scientific-industrial alliances and simplification of technology transfer.
- Science and technology policy creates an innovative ecosystem.
- The organizational model of science is research universities.
- A clear, successful policy of ensuring the immigration of "the world's best brains."
- Functional scientific-technical diversity development is emphasized.
- The main criterion for granting a person the status of researcher or scientist is the direct evaluation of scientific activity results. The advantage of this approach is the potential to make scientific discoveries by recognized scientists and emerging, talented researchers [22].

Very interesting is the Republic of Korea's scientific-educational system, which includes several requirements: a scientific degree, English proficiency, active participation in international retraining, wide opportunities for foreign scientists to work in the country, and others. At the same time, contrary to the global trend, the high status of higher education is firmly maintained here; university programs are not reduced, great attention is paid to ideological education during the training of civil servants, which is consistent with the Korean national value system [23]. The foundation of the scientific-educational system's development is the teacher-training system. Great importance is placed on the relevance of education; annual attestation requirements for teachers are established, and teacher selection and training are conducted through an entirely competitive system. Researchers also emphasize the importance of the teacher's social role in society, the collectivist characteristics of Asian countries, efforts to make individuals part of that collective, and the strict hierarchy. The Republic of Korea encourages the education of foreign students through various programs. The main directions of state support are regulated by law; the main scholarship program is "KGSP" ("Korean Government Scholarship Programs"), which includes payment of the full cost of tickets (one-time, both directions), certain material support for entry, monthly scholarship (90,000-100,000 won, which amounts to about 200 thousand drams in Armenian currency), medical insurance, coverage of language course costs, diploma thesis printing costs, additional payment for high knowledge of Korean language and scientific research [24].

The Republic of Armenia Law "On Scientific and Scientific-Technical Activity" was compared with the model law (approved by Decision N31-15 of the 31st plenary session of the Inter-Parliamentary Assembly of CIS member states on 25.11.2009). In the Republic of Armenia's law, the terms scientific and scientific-technical activity have a unified character, whereas in the model, they are separate, with fundamental and applied types assigned to both. In the model, types of scientific-technical activity are research, experimental design, project-experimental, preparation of experimental samples, etc. It is characteristic that, in the model, scientific-methodological, patent-licensing, software provision, organizational-methodological work, as well as the dissemination and application of their results, are also considered scientific-technical activity. Unlike the Republic of Armenia law, in the model, a scientist is a person who has a scientific degree and title and is recognized by the scientific community within the given professional framework. Very important are the definitions of the "scientific work" and "scientific result" concepts, which are also absent from the Republic of Armenia's law.

## Conclusion

Legislative regulation of the "scientific work" concept is very important, since we often encounter provisions using it in the Republic of Armenia legislation, particularly as permissible work for those occupying public service positions, for applying tax privileges, and other purposes. Also very instructive are the legislative regulations of China and Korea that encourage the activities of domestic and foreign scientists in their countries, as well as the opportunities offered to foreign students. The value of science lies in the useful application of its results, which increases the country's and people's prosperity. This understanding has long existed in the USA, which is why they adopted the Bayh-Dole and Stevenson-Wydler Acts [29]. Thus, the Bayh-Dole Act is aimed at patenting and commercializing scientific results, allowing scientific organizations, including universities, to profit from their intellectual activity. The Stevenson-Wydler Act governs the process for technology transfer between the public and private sectors.

### Policy Implications

Studying certain legislative acts of various countries, the following definitions are proposed: "scientific work is research conducted for the purpose of obtaining scientific results," "scientific result is new knowledge obtained during fundamental research.?" Mental and applied research, which is recorded on scientific information carriers - reports, scientific articles, scientific reports, scientific communications about conducted scientific research work, published monographs. "There is a need to apply the Korean experience in Armenia: not to reduce university programs, but to strengthen the high standard of higher education. Optimizing the system should be combined with substantive changes, and during the training of civil servants, great attention should be paid to ideological education that aligns with the Armenian national value system. In the Republic of Armenia, it is necessary to implement the American experience of science development based on the principle of synergy between higher education, the state, and private business. We believe that the main criterion for the effectiveness of scientific organizations and scientists' activities in the Republic of Armenia should also become the applicability of scientific results.

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# THE ROLE OF STARTUPS IN THE MODERN ECONOMY

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**Abstract:** In the digital economy, startups have become key engines of innovation, job creation, and economic growth across the world. This article examines the multifaceted roles of startups (particularly in the IT sector) and their capacity to reshape markets, attract foreign investment, and promote inclusive development. The topic is especially relevant for emerging economies like Armenia, where understanding the broader impact of startups is essential for designing effective, long-term growth policies.

The primary aim of this study is to assess the significance of startups in Armenia's economic transformation by analyzing global trends alongside national practices that facilitate their creation and success. Specifically, the article pursues three objectives: evaluating the impact of startups on different economic sectors, examining their role in employment and human capital development, and investigating their macroeconomic contributions, particularly in attracting foreign investment.

Descriptive, comparative, and qualitative research methods were applied. The findings highlight the vital role startups play in economic diversification, the expansion of skilled employment, and the internationalization of local talent and innovation.

The study concludes that startups are indispensable for advancing technological development and strengthening Armenia's competitiveness, supported by appropriate government policies, financial instruments, and educational programs. While challenges remain, such as high levels of uncertainty and limited early-stage funding, high-growth startups generate substantial positive effects on the economy. Therefore, fostering a supportive and resilient ecosystem is crucial to enabling these enterprises to flourish and sustaining Armenia's progress toward becoming a regional innovation hub.

**Keywords:** startup, innovation, economic development, foreign investments, job creation, education

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## Introduction

In the digital economy, startups have emerged as key drivers of innovation, job creation, and economic development worldwide. This article explores the multiple roles of startups (particularly in the IT sector) and their capacity to transform markets, attract foreign investment, and foster inclusive growth. Unlike traditional businesses, startups bring fresh ideas, disrupt existing markets, and adapt quickly to evolving global trends. Armenia, like many emerging economies, has embraced the startup movement as a pathway to strengthen its IT sector, create high-quality jobs, and attract foreign investment. This article explores the evolving role of startups in Armenia's economy, highlights key players and success stories, and discusses how

supportive ecosystems, including accelerators, venture capital funds, and government initiatives, are driving the country's transformation into a regional hub of innovation.

The main purpose of the study is to highlight the significance of startups in shaping Armenia's economy.

The relevance of the topic. Examining the role of startups in the digital economy is essential for understanding their diverse economic impacts and for shaping effective policies that promote sustainable growth, particularly in emerging markets.

The main purpose of this article is to explore the role of startups in the economy, highlight their significance in shaping Armenia's economic development, and examine both global trends and national practices that support their emergence and success. The following problems are set to achieve the purpose:

- To analyze the impact of startups on various sectors of the economy,
- To explore how startups influence employment and the development of human capital.
- To investigate their macroeconomic effects, particularly in attracting foreign investments.

### Literature review

The role of startups in the modern economy has attracted significant attention in both academic and industry research. Scholars and practitioners emphasize their contribution to innovation, job creation, and market transformation, noting that startups serve as catalysts for technological progress and economic growth. There isn't a single clear definition of a startup—different authors describe it differently depending on factors such as the company's stage in its lifecycle, age, business model, growth trajectory, and sector of activity. Start-ups are small, emerging firms—often founded by engineers or technologists—that experience rapid growth and innovation, typically in high-tech industries like IT. These firms begin with limited resources and informal structures, but may evolve into medium or large enterprises through strategic human resources development practices, strong leadership, and organizational culture [1]. Some authors argue that a company can be considered a startup based on four key factors: when it was founded, its level of innovation, its potential for growth, and the degree of risk or uncertainty it faces [2]. The term "startup" can be understood in two different ways. The first, broader definition focuses on business dynamics and the role of young innovative firms, where "startups" refer to all new companies, including many small businesses with limited growth ambitions. The second, narrower definition typically applies to venture-capital backed companies that have high growth potential, often in a specific sector, and are focused on rapid expansion [3]. E. Ries defines startup as an institution which is created by people and its main purpose is to develop new products and services under highly unstable conditions [4].

According to L. Steigertahl and Dr. René Mauer [5] the term "startup" does not have a formal definition, but it is generally understood to refer to a company that meets the following three key criteria:

- it is relatively young (usually less than 5 to 10 years old),
- it focuses on innovation,
- it has the intention to scale, meaning it aims to grow its workforce and expand into new markets.

Startup can be defined as an entrepreneurial initiative with high growth and innovation potential that drives smart, inclusive economic growth by attracting foreign investment, boosting high value-added sectors, enhancing competitiveness, and creating skilled

employment [6]. The five stages of development of an innovative enterprise, as distinguished by S. Dutta [7], are: pre-seed, seed, startup, growth, and expansion/market leadership.

Among Armenian authors, R. Babayan has addressed the main problems Armenian startups face, including lack of strategic planning, insufficient market research, inadequate financial planning, talent acquisition and retention challenges, ineffective risk management, inadequate development of the business model, limited access to mentorship and support, and limited access to funding [8]. Another group of Armenian economists [9] conducted research on the startup ecosystem and concluded that it is still in its early stages of development. To foster its growth, initiatives are needed to support startups in the pre-seed and seed stages, helping them mature and become future leaders and promoters of Armenia's startup ecosystem. A startup is a company focused on developing innovative technologies and business models to meet the needs of global consumers. It differs from service-oriented firms by requiring distinct practices and skills, and relies on local and global innovation networks for talent, knowledge, funding, and partnerships [10].

### Methodology

In the scope of this research, descriptive, comparative, and qualitative methods were used and implemented. The results can be valuable to policymakers, researchers, and individuals interested in entering the IT sector with innovative ideas, as they offer meaningful insights into international practices and the role of startups in economic development.

### Analysis

Although definitions of startups vary among authors worldwide, one thing is certain: startups play a vital role in economic development, particularly in the IT sector. Consequently, national policies should prioritize creating supportive conditions for their emergence, growth, and long-term success.

Startups play a significant role in modern economies by driving innovation, creating jobs, increasing competitiveness, and boosting productivity. Compared to traditional companies, they are more flexible, allowing them to respond quickly to market demands and technological changes. Even failed startups can play an important role in improving supply and increasing competitiveness [11]. In Armenia, the development of startups has become a new and promising direction for the economy over the past decade. They play a key role in promoting innovation, creating high-quality jobs, and enhancing competitiveness in international markets. Their innovations are often transferred to other sectors as well, contributing to industrial modernization and the transition to digital technologies. A good example is the Romanian startup UiPath, founded in 2005 by a small team of 10 people to automate back-office tasks. Over time, it grew into a global company, and its technology is now used in sectors like healthcare (to automate patient records), banking (for compliance checks), and insurance (to process claims), helping reduce costs and errors.

Their role in boosting employment is also considerable. While each startup may employ a relatively small number of people, their cumulative impact on job creation is substantial, and they contribute to the development of professional skills. OECD's report shows that even though only about 3% of startups grow significantly, the number of new jobs created by them is remarkably big: ranging from 21% in the Netherlands to 52% in Sweden. This is very important for policy makers to understand. It is emphasized that despite the fact that most startups stay

small or grow slowly, the policy makers should not underestimate how important are the few fast-growing start-ups for creating jobs. These young, growing companies are key drivers of employment and economic growth [12]. Studies have shown that just 1% of the fastest-growing startups are responsible for creating about 40% of all new jobs in a year [13]. Startups play a key role in breaking market stagnation and creating new jobs, especially during times of uncertainty. Their success depends on entrepreneurs' skills, innovation, and experience, often gained through education and business incubation [14].

In Armenia, the IT sector has become one of the key drivers of employment, offering high-paying, competitive, and quality job opportunities, especially for the younger generation.

In recent years, the number of professionals working in the IT industry has steadily increased, encompassing not only programmers but also data analysts, cybersecurity specialists, project managers, and other technical and business roles. This sector has also contributed to the growing participation of women in technology-related jobs, while remote work enables many highly qualified professionals to work for leading international companies without leaving the country.

Armenia has become the birthplace of several successful startups that have gained international recognition. For example, Picsart, founded in 2011, is a globally known platform for online photo and video editing. In Armenia, the company has also established Picsart Academy, an educational institution aimed at training specialists in various tech fields, where students learn through real-world projects and become competitive professionals.

Another success story is Krisp, a startup that uses AI technologies to significantly improve digital voice communication. Its advanced features include noise cancellation, voice enhancement, accent transformation, call recording, summarization, and more. Today, Krisp processes around 75 billion minutes of audio per month and has logged over 50 million recorded calls. One of its latest innovations allows transforming Indian-accented English into American-accented English. Although the company is headquartered in California, it maintains offices in Yerevan, with employees free to work remotely. The Armenian startup Docus was also included in Ahrefs' list of the top 50 trending SaaS startups. Docus provides a platform that connects leading doctors from the U.S. and Europe with hospitals in developing countries, enabling access to expert medical consultations worldwide.

From a macroeconomic perspective, startups often serve as a source of foreign direct investment by attracting international venture capital which brings not only financial resources but also global expertise and networks. This inflow of capital enhances domestic innovation capacity, stimulates job creation, and supports long-term economic growth. Innovative potential plays a crucial role in attracting foreign investment, as investors prioritize countries with strong R&D spending and stable economic and political conditions. In the digital era, innovation enhances a country's global competitiveness and resilience to economic crises, making it more appealing to international investors [15]. One of the notable examples of attracting foreign investment through a strong innovative environment is the strategic cooperation between the European Union and Vietnam. Established in 1998, the European Chamber of Commerce in Vietnam (EuroCham) represents over 1,400 European companies, making it one of the largest foreign business chambers in the country. According to EuroCham Chairman Bruno Jaspaert, confidence in Vietnam's investment climate remains strong, with 72% of surveyed European business leaders consistently recommending Vietnam as an investment destination. Although global trade tensions are growing, most European businesses in Vietnam have not yet felt major financial effects. The political situation is changing, but its impact on companies in Vietnam has

been limited so far. This stability, along with Vietnam's strong focus on innovation, continues to make the country a top choice for European investors [16].

Estonia has emerged as the undisputed startup capital of Europe, boasting the highest number of startups and unicorns per capita on the continent. With just 1.3 million people, Estonia has produced 10 unicorns, including Skype, Wise, Bolt, and Pipedrive and it has the most unicorns per capita in Europe. This success is largely driven by its digital-first governance, with 99% of public services available online and the ability to register a startup in just 15 minutes. Estonia's simple and transparent tax system, with 0% corporate tax on reinvested profits, its e-Residency and Startup Visa programs, and strong legal protections create an environment that attracts investors from all over the world. The country's startup ecosystem supports over 10,000 employees. With 1,314 startups and 150+ support organizations, Estonia fosters a collaborative, mentoring-driven culture [17]. This innovation-focused environment has made Estonia not just a hub of European entrepreneurship, but a global model for startup success.

Startups that secure foreign capital in their early stages are significantly more likely to relocate their headquarters, often as a condition of funding. For instance, the study shows that one out of ten U.S. venture capital deals leads to the startup relocating its headquarters to the U.S., indicating that investors often prefer startups to relocate closer to established innovation hubs, where they can more effectively support their growth, facilitate access to networks, and enhance opportunities for scaling and successful exits [18].

Startups significantly boost export volumes, as many of them provide digital services to international clients. By creating value primarily through intellectual property, they attract foreign investment without requiring substantial material resources. Some operate in global markets, showcasing Armenia's technological potential. Startups have the capacity to become a key driver of Armenia's future economic growth and innovation potential. Within the framework of the state strategy for the development of IT and high technologies, a favorable environment has been created for startups. Existing tax incentives, along with the presence of venture funds, incubators, and accelerators, promote the establishment and growth of startups.

Armenia StartUp Academy has played a vital role in fostering Armenia's startup culture. It has provided early-stage startups with valuable opportunities to acquire practical skills essential for company development and for entering international markets. After completing a 12-week training program, successful graduates have the opportunity to present their ideas, products, and services to both local and international investors during a Demo Day event. StartDoon is an important accelerator that helps Armenian startups grow and expand into new markets. As a French-Armenian initiative, it connects local startups with experienced French experts who offer guidance in business development, strategy, and international growth. By building strong partnerships and providing practical support, StartDoon equips Armenian startups with the tools and knowledge they need to succeed both at home and abroad.

Granatus Ventures, SmartGateVC and Formula VC are venture capital funds that invest in early-stage startups across various sectors. The FAST Foundation's Budding Entrepreneurs and Startup Studio programs, in turn, provide support to early-stage entrepreneurs and more mature startups, respectively. The BANA business angel network is also an important initiative, which consists of experienced entrepreneurs, investors, and executives from Armenia and abroad. It serves as a bridge between investors and startups, facilitating the rapid development and growth of startup ventures. At the same time government initiatives such as "Digital Armenia" support infrastructure development.

The development of the IT sector and startups has a significant impact on education and the growth of human capital. Demand for IT professionals stimulates both the expansion of IT-related university programs and the spread of non-formal education such as online courses, coding schools, and training programs. Beyond Yerevan, the startup culture is gradually expanding to the regions, helping to extend economic activity beyond the capital and promoting regional development. The IT sector not only creates jobs but also fosters a new culture of skills-based education, emphasizing hands-on learning, project-based thinking, and continuous self-improvement.

As we can see, the development of startups not only boosts the IT sector but also plays a key role in job creation, the growth of a learning culture, and the advancement of education. These companies attract foreign investment and contribute to increasing exports, helping the country gain international recognition through the innovative solutions and services they offer worldwide.

### Conclusion

Startups have become a key force in shaping the modern digital economy. They not only drive innovation and technological advancement but also play a vital role in job creation, skill development, and enhancing national competitiveness. This is particularly evident in developing countries like Armenia, where the growing startup ecosystem (supported by favorable government policies, venture capital, and educational initiatives) has led to the emergence of globally successful companies.

The analysis demonstrates that startups contribute significantly to economic diversification, attract foreign investment, and facilitate the internationalization of local talent and ideas. Despite challenges such as high uncertainty and limited early resources, high-growth startups have a significant positive economic impact; therefore, creating a supportive environment for their development is critical.

### Conflict of Interest

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# CIRCULAR ECONOMY IN THE CONTEXT OF FOOD SECURITY

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**Abstract:** Ensuring food security is one of the major global challenges facing humanity. This issue is becoming even more critical in the context of a growing world population, inefficient use of limited resources, rising global waste (particularly food waste) climate change, and an increasing number of undernourished people. These trends highlight the urgent need to organize economic systems in ways that help mitigate such global problems. In recent years, the circular economy has emerged as a promising approach, which underscores the relevance of this article.

The aim of the article is to develop a set of measures for introducing circular economy principles into agriculture in order to enhance the level of food security in the Republic of Armenia. To achieve this objective, the study examines global food security issues, outlines the negative consequences of a linear economic model, identifies the key principles and advantages of a circular economy, substantiates the importance of applying circular approaches in agriculture, and assesses the current state of food security in Armenia. The research employs historical, analytical, comparative, abstract, and statistical methods.

The findings indicate that the linear economic model is no longer sustainable. Addressing food security challenges requires a transition to a circular economy framework at the individual, organizational, state, and global levels. If the recommended measures for implementing a circular economy in the context of food security are adopted by the Republic of Armenia and other developing countries, they can help solve not only food security issues but also reduce waste, improve the efficient use of natural resources, preserve ecosystems, and address a range of related problems.

**Keywords:** global challenges, food security, linear economy, circular economy, food waste, circular economy actors

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## INTRODUCTION

Today, the world faces a number of global challenges that pose a serious threat to humanity. In particular, according to UN forecasts, the world population, which actually stood at 8.2 billion in 2024, will reach 10.3 billion in 2084 [1]. The world is currently facing an extreme food security situation, with 280 million people worldwide facing hunger every day [2]. It is obvious that this problem will become even more acute as the population grows. The main problem with food security, especially in developing countries, is high food prices, which force poor families to spend the majority of their income on food [3]. The solution to world hunger is not to lower food prices, but to increase people's incomes [4]. At the same time, it should be noted that the distribution of world food between different countries is highly uneven, which is due to both economic and political reasons. Food waste is higher in developed countries, accounting for

approximately 40% of food produced. The causes of food waste vary from country to country. For example, in developed countries, food waste is driven by overproduction and consumer behavior. And in developing countries, the causes of food waste are underdeveloped infrastructure, non-innovative storage approaches, consumer behavior, inefficient organization of production processes, etc. It should also be noted that 2.01 billion tons of solid waste are generated worldwide annually, a figure predicted to reach 3.4 billion tons by 2050, causing significant environmental damage [5].

To satisfy their needs, humans use natural resources, which are physical or biological formations found in nature [6]. Studies by various organizations show that demand for natural resources will continue to increase in the coming decades. Thus, by 2030, the demand for energy will increase by 50%, the amount of minerals, ores, fossil fuels, and biomass consumed globally per year by 2050 will increase by almost three times, and the demand for water used for various purposes will increase by 50% [7]. Currently, there is already an objective need for effective management of natural resources. The management of natural resources such as land, water, plants, animals, etc. focuses on how their use affects current and future generations [5]. Agricultural activity is one of the sectors with the greatest negative impact on nature, resulting in a reduction in biodiversity, including flora and fauna. To meet the growing demand for food, pesticides have been used, which have a negative impact on food quality and human health [8].

Taking into account the above, an objective need has arisen to develop and implement approaches to economic activity that will enable more effective solutions to address issues related to food security. All of this has determined the relevance of the presented article.

This article argues that implementing circular economy measures in agriculture is central to increasing food security in the Republic of Armenia. The aim is to propose actionable steps that enable this transformation. To achieve the set goal, the following tasks have been set:

- study the main issues related to global food security,
- present the negative consequences of organizing a linear economy,
- Identify the main principles and advantages of the circular economy.
- justify the importance of applying a circular economy in agriculture,
- present the current state of food security in Armenia.

## LITERATURE REVIEW

The main goal of economic activity is the maximum satisfaction of people's unlimited needs within the framework of limited resources. Morselettp P. in his study shows that the economy has always been a mix of circular and linear applications but in varying proportions [9]. The linear economy has been applied since the industrial revolution, the essence of which is that the resources used in the production and consumption process turn into waste after the first use [10]. In a linear economy, the transformation of resources into products is accompanied by resource consumption, elimination, and environmental pollution. Studies have shown that the linear economy is no longer justified and there is a need to transition to a new economic model, which is the circular economy (CE). There are over 100 definitions of the circular economy. The main idea of the circular economy is the efficient use of limited resources and the reduction of waste. In general, the circular economy includes the 10Rs framework. Rethink (change current lifestyles, strategies, policies, and the way products were designed, made, and used to meet the

needs of a CE), Repurpose (use products for multiple purposes), Refuse (don't use toxic materials and non-renewable resources in the design, make, and consumption of products), Reduce (decrease resources in production and consumption, generating value while decreasing environmental impact), Reuse (find new product uses (second hand products)), Repair (maintain and repair products to avoid wasting), Refurbish (improve products that bring more value and decrease environmental impacts), Remanufacture (create new products from second hand products), Recycle (process waste materials into products or reuse the raw materials of products), Recover (recover energy from waste, recovering eco-systems and resources) [11]. F. Sariatli notes that the circular economy implies a conception or system that keeps the added value of a product as much as possible and eliminates the waste [12]. The organization of a circular economy is conditioned by certain costs, which are largely associated with the introduction of the latest technologies. It should be noted that the circular economy requires not only innovative technologies, but also innovative participants who are ready for change in terms of both new policies and decision-making tools [13].

According to H. Katunar, circular economy in agriculture provides environmental advantages, and when applied in the long term, it can also provide economic and social benefits [14]. Food is a key concept in the Sustainable Development Goals, and a circular economy in agriculture can contribute to achieving other sustainable development goals, such as eradicating world hunger, achieving food security and sustainable agriculture, improving health and well-being, reducing food waste, managing natural and other resources effectively in consumption and production processes, reducing water pollution, and preventing land degradation worldwide [15]. Rood et al. concluded in their scientific paper that an innovative food system through a circular economy contributes to the regeneration of natural capital in the food value chain, new processes for processing food waste, as well as the establishment of sustainable food security [16]. Through a circular economy, the dangers and risks caused by climate change become manageable, which makes it possible to reduce negative impacts on the environment and ensure a healthier lifestyle [11]. Scientific research on the circular economy has been conducted since the early 2000s. In this regard, China, Japan, and EU countries are among the leading countries [11]. However, studies on the circular economy in the context of food security are only a decade old. As for the Republic of Armenia in particular, some theoretical work has been carried out in this direction over the past few years. There is much work to be done here to achieve greater economic, social, and environmental benefits.

## METHODOLOGY

Historical, analytical, comparative, abstract, and statistical methods were used for the studies. The analysis was based on numerical data and publications from international organizations, as well as from the Statistical Committee of the Republic of Armenia.

## DISCUSSION

Relations related to ensuring food security in the Republic of Armenia, as well as the main directions of state policy in regulating this sector, are regulated by the Law of the Republic of Armenia "On Ensuring Food Security", adopted in 2002 [17]. In 2023, the Government of the Republic of Armenia adopted the "Food Security System Development Strategy", the main goal

of which is to ensure physical and economic access to food that meets health standards for all groups of the population, as well as to create prerequisites to withstand adverse changes in the domestic and foreign markets and the negative consequences of possible emergency situations [18]. Armenia has achieved a high level of self-sufficiency in potatoes, vegetable crops, fruit, grapes, sheep and goat meat, eggs, and fish. An above-average level of self-sufficiency is ensured for beef, pork, and milk. The level of self-sufficiency remains extremely low, especially in vital food items such as wheat, pulses, vegetable oil, poultry meat, and sugar.

Food losses have become a serious problem in the Republic of Armenia. Losses refer to the volume of food that is destroyed or unfit for consumption at all stages of transportation and storage, from production (after harvest), processing and storage to consumption. The extent of losses depends on the presence of imperfect sales and storage systems [19]. According to 2018 data, the amount of losses (calculated at retail prices) for certain types of vegetables alone amounted to about 37 billion Armenian drams. It is noteworthy that this amount significantly exceeded the volume of vegetable imports during the same period. In addition, according to experts, a significant part of the losses is due to the traditional culture of food consumption in households, the low level of organization of the domestic market and local production, as well as the unsustainable use of food surpluses and residues in the public food sector [20]. In Table 1, the total food supply and food losses are presented.

Table 1

Supply and loss volumes of selected food products, thousand tons (2024)<sup>1</sup>

Food type	Total supply	Losses	Percentage (%)
Wheat	907.8	37.4	4.1
Potatoes	501.7	19.1	3.8
Vegetables and melons	1025.1	94.4	9.2
Fruit and berry (except grapes)	510.2	19.7	3.9
Leguminous crops	10.1	0.1	1.0
Eggs	40.7	1.0	2.5
Milk	832.8	9.2	1.1
Beef	69.0	0.3	0.4
Poultry	56.8	0.2	0.4
Grapes	206.2	5.5	2.7

As can be seen from the table, the largest losses occur in vegetables, which account for 9.2% of the total. Wheat is in second place with this indicator at 4.1%, followed by fruit and berry at 3.9%. The least food waste comes from poultry, at 0.3%. Table 2 presents the self-sufficiency levels of key food commodities for 2022-2024.

Table 2

<sup>1</sup> The table was compiled and calculations were made by the author based on data published by the Statistical Committee of the Republic of Armenia: Food Security And Poverty, January – March 2024, Yerevan, 2025, Armstat, Statistical Bulletin, p. 63-71,

Food Self-sufficiency ratio, % <sup>2</sup>			
Food type	2022	2023	2024
Wheat	24,4	27,9	22,8
Potatoes	98,4	99,2	106,2
Vegetables and melons	102	97,4	99,6
Fruit and berry (except grapes)	102	103,1	100,5
Leguminous crops	26	35,2	38,4
Eggs	99,2	98,8	98,9
Milk	83,4	80,2	78,6
Beef	89,7	90,7	88
Poultry	25,3	25,4	26
Grapes	106,6	106,6	103,7

Considering the low level of food security in the Republic of Armenia and the presence of food waste, there is a need to transition to a circular economy at the levels of individuals, organizations, and the entire state, and recommendations related to this are presented in the suggestions section. Humanity causes enormous damage to the planet with the waste generated by its economic activities. Added to this is the inefficient use of limited natural resources. These two main problems can be solved through the circular economy model, where waste reuse makes it possible to reduce the amount of waste and the volume of resources used (Figure 1) .

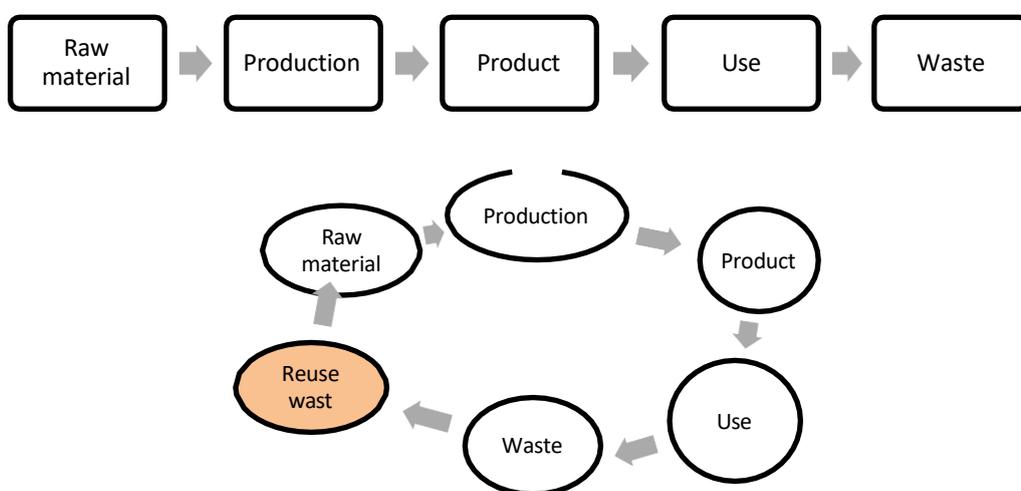


Figure 1. The value chains of linear economy and circular economy models<sup>3</sup>

The practical application of the circular economy model, in general and in the agricultural sector in particular, poses several challenges. In particular, M. Haji-Rahimi et al. have identified 16 such challenges. They mentioned the following as such challenges:

<sup>2</sup> The table was compiled and calculations were made by the author based on data published by the Statistical Committee of the Republic of Armenia: Food Security And Poverty, January – March 2024 , Yerevan, 2025, Armstat, Statistical Bulletin, p. 63-71,

<sup>3</sup> The diagram was composed by the author.

- conducting agricultural activities using traditional methods,
- low literacy level among farmers,
- small and fragmented agricultural plots,
- low productivity of agricultural activities,
- containment of agricultural product prices,
- irrational subsidies provided for pesticides and fertilizers,
- insufficient means of product storage,
- improper and unscientific use of agricultural inputs,
- high prices for precision farming equipment,
- weakly developed transport infrastructure,
- insufficient internet connection infrastructure,
- lack of banking services,
- shortage of personnel in the field of agricultural research,
- the weak link between research, education, innovation, and farmers,
- the lack of workshops that recycle industrial waste,
- Insufficient rural and agricultural wastewater treatment facilities [20].

Meanwhile, Dumitrescu-Popa I. S., and others have noted inequality in society and consumer behavior as challenges on the path to a circular economy [21]. One of the most important challenges in the transformation to a circular economy is the appropriate legal and regulatory mechanisms that govern economic processes, product design, intellectual property rights, and cross-border trade. The complex interactions between the legal framework and innovative approaches required for a circular economy present both opportunities and threats [22].

It is worth noting that all the challenges mentioned above related to the implementation of the circular economy model also exist in Armenia. Therefore, the introduction of the circular economy model must begin with measures to eliminate these challenges.

## CONCLUSION

Considering the huge volumes of waste generated on planet Earth, as well as the growing demand for natural resources, as well as the number of hungry and malnourished people in the world from the perspective of food security, we can conclude that the negative social and environmental consequences of the linear economy are greater than its economic benefits, which is why there is an objective need to increase the share of the circular economy in the overall economy. The introduction of a circular economy is impossible to imagine without numerous, diverse obstacles. These obstacles relate to both a country's socio-economic situation and people's behavior, as well as to societal inequality and gaps in the legal framework.

If we summarize the results of our research, we can present the following definition of a circular economy in the context of food security: “In agriculture, the circular economy is the process of achieving greater quality and quantity of food through more efficient resource management and less waste generation” . In this regard, September 29 is an important day, which is a day for disseminating information on food loss and waste and implementing appropriate measures. The day is co-convened by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP). This year, it will be awarded for the 6th time [23].

### Policy Implications

To manage and reduce food waste and ultimately ensure greater food security, it is crucial to develop a systemic approach among all participants in the circular economy, grounded in a caring attitude towards nature. In the context of food security, circular agriculture should be implemented at three levels: the state, food producers, and consumers.

At the state level, developing an appropriate legislative framework for the circular economy is important. It is proposed to develop and implement the RA Law "On Promotion of the Circular Economy", which should regulate relations related to the organization of the circular economy in all sectors of the economy. Then, other sub-legislative acts arising from that action should be developed, through which separate action plans will be defined. As already mentioned, the circular economy is based on innovation. Here, the work of the scientific community (scientists and researchers) in this direction is emphasized, with solutions aligned with international experience. It is important to apply tax incentives and other incentives to all participants in the food value chain who will implement the circular economy model in their activities. As well as imposing certain sanctions on those businesses that operate in a linear economy model, contributing to increased waste and the supply of non-organic food. Disseminate information about the circular economy through all possible means (television, radio, and YouTube programs, social networks, seminars, informational brochures, etc.). September 29, as the International Day of Awareness of Food Loss and Waste (IDAFLW), should be celebrated with even greater pomp and scale. The state, using all its structures and capabilities, should establish close cooperation between various specialists (ecologists, economists, technologists, IT specialists, scientists, businessmen, etc.). It is possible to effectively organize a circular economy across larger land areas, which is why the state should continue its work to create cooperatives that will enable larger land plots.

Food producers must transition to a circular economy model. Here, the use of plant residues and animal manure to produce organic fertilizer is emphasized, as is the widespread use of drip irrigation and rainwater in the Republic of Armenia's agriculture. Proper crop rotation is also important for maintaining soil fertility. To organize circular agriculture more effectively, the branches of animal husbandry and crop production should be combined. Composting plants should be built directly on the farm. To reduce transportation costs and prevent food loss during transport, it is necessary to organize the production and processing of agricultural products closer to cities. It is necessary to replace outdated technologies with the latest ones.

Consumers need to change their behavior to effectively organize a circular economy. It is necessary to develop a caring attitude towards the environment among them. Proper garbage sorting is important here. To reduce food waste, consumers need to better estimate their food needs and throw away less food. It is proposed to impose penalties on consumers who generate more food waste than the prescribed amount or who do not dispose of it in the designated bin. In summary, a circular economy model benefits everyone: the state, producers, consumers, and, most importantly, nature and future generations.

### Conflict of Interest

The author declares no conflicts of interest.

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## INNOVATIVE DEVELOPMENT: GLOBAL LESSONS AND NATIONAL PRIORITIES

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**Abstract:** In the context of globalization and rapid digital transformation, innovative development has become a decisive factor shaping the competitiveness and sustainable growth of national economies. Countries that successfully integrate innovation into their strategic management frameworks are able to maintain resilience, attract investment, and ensure long-term economic progress. However, many developing economies still face serious challenges that limit their innovative potential.

The purpose of this article is to identify the main issues of innovative development and to analyze possible directions for strengthening strategic management of the economy through the adoption of international best practices. The research highlights a number of persistent problems, including insufficient investment in research and development (R&D), weak cooperation between science and business, institutional barriers, and the outflow of qualified human capital. These issues create a gap between innovative potential and actual performance, slowing down the pace of transformation.

The methodological basis of the study is a comparative analysis of international experiences, focusing on the cases of South Korea, Israel, and Estonia, which have achieved remarkable results in fostering innovation-oriented growth. Their models demonstrate how state policy, private sector initiatives, and academic research can be effectively combined within a unified strategy.

The results of the study show that for countries such as Armenia, integrating innovation policy with strategies of digital transformation and green growth is essential for achieving sustainable competitiveness. The findings suggest that national priorities should be reoriented toward creating favorable conditions for R&D investment, strengthening innovation ecosystems, and enhancing strategic coordination between key stakeholders.

**Keywords:** innovation, strategic management, competitiveness, digital transformation, sustainable growth, science-business cooperation, national economy

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### Introduction

In the context of globalization and rapid digital transformation, innovative development has become a fundamental driver of economic growth and national competitiveness. Innovation

is no longer a matter of choice but a necessity for ensuring resilience, attracting investment, and improving the quality of life. Under these conditions, strategic management of the economy goes beyond traditional planning and resource allocation. It increasingly involves building institutional and structural frameworks that stimulate innovation and foster sustainable development.

Despite the growing importance of innovation, many developing economies, including Armenia and other post-Soviet states, continue to face significant challenges. The most pressing problems include:

- insufficient investment in research and development (R&D);
- weak cooperation between science, business, and government institutions;
- outflow of qualified human capital (brain drain);
- institutional inefficiencies and low effectiveness of strategic management mechanisms;
- limited adoption of digital and green technologies across key sectors of the economy.

These challenges create a substantial gap between innovative potential and its actual realization, slowing down the pace of transformation.

The purpose of this study is to identify the key issues hindering innovative development in Armenia and to outline possible directions for improving strategic economic management by integrating international experience with national priorities.

## Literature Review

The relevance of this research lies in the urgent need to embed innovation policy into the broader framework of digital transformation and sustainable growth. The methodological approach is based on a comparative analysis of international practices, focusing on their applicability to developing economies, with a particular emphasis on Armenia. This allows the study to draw not only global lessons but also national priorities for designing an effective innovation strategy.

The issues of innovative development and strategic management of the economy have been the subject of significant academic debate for decades. The roots of the discussion can be traced back to Joseph Schumpeter [1], who conceptualized innovation as the “engine of economic development,” emphasizing the role of entrepreneurship and creative destruction in driving economic dynamics. His ideas were further developed in the framework of evolutionary economics by Richard Nelson and Sidney Winter [2], who analyzed technological change as a path-dependent process, shaped by routines and institutional environments.

The role of innovation in shaping national competitiveness was systematized by Michael Porter [3] in *The Competitive Advantage of Nations*, where he highlighted clusters and innovation-driven strategies as critical factors for long-term success. Later, David Teece introduced the concept of dynamic capabilities, stressing the ability of organizations and economies to adapt and reconfigure resources in rapidly changing environments [4].

Contemporary scholars continue to focus on the relationship between innovation, strategic management, and sustainable development. Manuel Castells examined the rise of the network society and the transformative role of digital technologies. Martin Hilbert analyzed the digital divide as a dynamic phenomenon, underlining its impact on growth in developing countries [5]. Reports by the OECD and the World Bank highlight the necessity of integrating digital transformation and green growth policies to sustain competitiveness in a globalized economy [6][7].

In terms of practical lessons, countries such as South Korea, Israel, and Estonia are often cited as benchmarks of successful innovation-oriented strategies. Studies by Katz & Koutroumpis show how investment in digital infrastructure can foster inclusive growth and innovation ecosystems, while Mothobi & Grzybowski provide evidence from Africa on how infrastructure investment promotes digital service adoption [8][9].

For Armenia, recent international policy reviews reinforce the urgency to align national priorities with global innovation trends. The UNECE Innovation for Sustainable Development Review: Armenia maps the governance and ecosystem gaps and offers concrete recommendations [10]; the OECD report on the digital transformation of Armenian businesses focuses on SME digitalization levers and constraints [2]; WIPO's Global Innovation Index profiles Armenia's strengths and weaknesses across inputs/outputs [12]; and Armstat/SDG indicator 9.5.1 reports official metrics on R&D expenditure relative to GDP.

Thus, the literature reveals a consensus that innovation is a cornerstone of sustainable economic growth, but its successful integration into strategic management depends on addressing structural challenges such as R&D investment, institutional efficiency, and science–business cooperation. These insights form the analytical foundation of the present study, linking global lessons to the national priorities of Armenia and other developing economies.

## Methodology

This study applies a mixed-method approach that combines both quantitative and qualitative analysis. The comparative method was used to examine international best practices (Israel, South Korea, Estonia) and assess their applicability to the Armenian context. The analysis relied on data from the World Bank (2023), Armstat SDG 9.5.1, and the WIPO Global Innovation Index (2024), as well as policy reports by the OECD (2024) and UNECE (2023). This approach made it possible to identify the main barriers to innovation in Armenia (low R&D expenditure, institutional fragmentation, and brain drain) and outline potential strategies for overcoming them. Despite certain limitations, such as the scarcity of national microdata and differences in international methodologies, the chosen research design allowed linking global lessons with national priorities.

In addition, the study introduces a conceptual model that illustrates the relationship between innovation policy and sustainable growth. According to the model, increasing investment in R&D provides the foundation for strengthening the innovation ecosystem, where government, academia, and business cooperate. This ecosystem is then integrated with processes of digital transformation and green growth, generating a multiplier effect. The final outcome is improved national competitiveness, higher positions in international rankings, and sustainable economic development.

## Analysis

Innovation is increasingly recognized as a cornerstone of competitiveness and long-term sustainability. Countries that invest systematically in research, technology, and human capital demonstrate not only higher productivity but also stronger resilience to external shocks. For Armenia, the issue of innovation-driven development has become urgent: while the country has inherited strong STEM traditions and benefits from an active diaspora, structural barriers continue to constrain progress. Low investment in R&D, weak science–business cooperation, and persistent emigration of qualified professionals create a situation where available resources are

not fully transformed into sustainable growth. At the same time, examples such as Picsart and Krisp prove that Armenia’s talent pool is capable of global success, provided that the right ecosystemic conditions are in place.

This analysis seeks to evaluate Armenia’s innovation performance in comparison with both global leaders (Israel, South Korea) and a small but highly successful digital economy (Estonia). The countries were chosen deliberately: Israel demonstrates the power of state–business–venture collaboration; South Korea illustrates the effectiveness of massive state-led investment in technology; and Estonia provides evidence that even small states with limited resources can achieve global recognition through institutional reforms and digital governance. Armenia’s current position, its strengths and weaknesses, as well as potential pathways for reform, will be assessed through quantitative and qualitative indicators.

Table 1

R&D Expenditure and Global Innovation Index (2023–2024), [13][14]

Country	R&D Expenditure (% of GDP, 2022)	GII Rank (2024)
Israel	5.4	3
South Korea	4.9	6
OECD Average	2.7	–
Estonia	1.8	16
Armenia	0.24	63

Armenia’s expenditure on R&D stands at just 0.24% of GDP, more than 10 times lower than the OECD average and almost 20 times below Israel’s level. This chronic underfunding explains Armenia’s weak position in the Global Innovation Index (77th place in 2024). In contrast, Israel and South Korea have built innovation-oriented economies through consistent and large-scale investments. Estonia, despite its small size, allocates 1.8% of GDP to R&D, which, combined with institutional reforms, secures its place among the world’s top 20 innovators.

Table 2

Armenia – Strengths and Barriers in Innovation, [15][16]

Dimension	Strengths	Barriers
Human capital	Strong STEM base, diaspora networks	Brain drain (~35% STEM graduates emigrate)
Innovation inputs	Emerging digital startups	Low R&D spending (0.24% GDP)
Governance & institutions	Innovation included in SDGs	Fragmented policy, weak coordination
Business sector	SMEs open to digital adoption	Limited finance, weak science–business links
Sustainability agenda	Potential in green energy & construction	Lack of funding and incentives

The dual nature of Armenia’s innovation system is evident. On one side, the country benefits from solid foundations: highly skilled professionals, strong academic traditions, a globally dispersed but engaged diaspora, and the presence of digital startups. On the other side, systemic

weaknesses undermine these advantages. Emigration of skilled graduates reduces the available talent pool, while low R&D spending and weak institutional coordination prevent research results from being commercialized.

Table 3.

Researchers and Patents per Million Inhabitants (2022), [14]

Country	Researchers per 1M people	Patents per 1M people
Israel	8,250	1,200
South Korea	7,980	1,100
Estonia	4,100	220
Armenia	1,250	25

Quantitative indicators of human capital and patent activity highlight Armenia’s weak position. With only 1,250 researchers per million inhabitants, the country has a research density far below even small economies like Estonia (4,100). Patent activity is alarmingly low: just 25 patents per million people, compared to over 1,000 in Israel and South Korea. These figures suggest two key problems: the research base is too small to generate the necessary scale of innovation, and existing research does not translate effectively into applied technologies due to weak intellectual property protection and low commercialization.

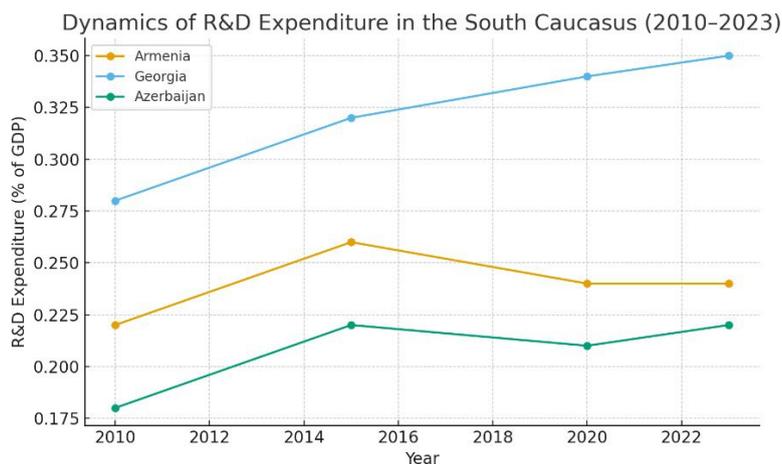


Figure 1. Dynamics of R&D Expenditure in the South Caucasus (% of GDP, 2010–2023)

The regional comparison reveals Armenia’s stagnation (Figure 1). Over more than a decade, Armenia’s R&D expenditure has hovered between 0.22–0.26% of GDP, showing no significant upward trend. Georgia, however, has gradually increased its investments, reaching 0.35% in 2023. Azerbaijan maintained stability around 0.22%, but even in this context Armenia risks falling behind, as its indicators show no dynamic growth. This stagnation reduces Armenia’s ability to compete regionally and erodes its potential attractiveness for international investors.

#### Conceptual Model: Pathway for Armenia’s Innovation-Driven Growth

In this study, the conceptual model is presented not as a mathematical formula but as an analytical framework that highlights the causal relationships between resources, processes, and outcomes in Armenia’s innovation system. Its role is to explain the logic of transformation: how increased R&D spending and institutional reforms can be converted into higher competitiveness and sustainable economic growth. The model provides three main benefits:

- It offers a step-by-step roadmap for policymakers to prioritize actions.

- It links inputs (resources) with outputs (results), showing why partial reforms without adequate funding or coordination are ineffective.
- It aligns national priorities with global megatrends, ensuring that Armenia's innovation policy is relevant in the international context.

Thus, the model is not only a theoretical construct but also a practical tool for designing policy measures that can enhance Armenia's innovation capacity.

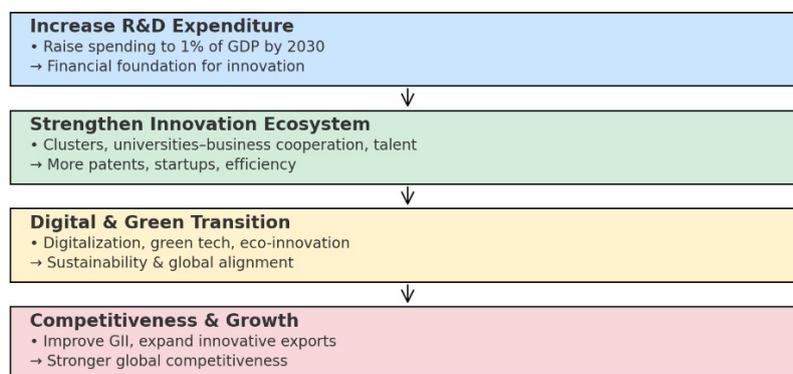


Figure 2: Conceptual Model of Armenia's Innovation-Driven Growth<sup>4</sup>

The model demonstrates that Armenia's current innovation stagnation is the result of insufficient investment and institutional inefficiencies. The first step emphasizes financial commitment: without reaching at least 1% of GDP in R&D expenditure, the country cannot expect a breakthrough. The second step highlights the ecosystem dimension — clusters and science–business collaboration are essential to convert research into economic outcomes. The third step underscores the need for alignment with international priorities, as competitiveness today depends on digitalization and sustainability. Finally, the fourth step projects the desired outcomes: higher positions in the Global Innovation Index, a stronger export base of innovative products, and greater economic resilience.

#### Explanation of the Conceptual Model

1. Increase R&D Expenditure to 1% of GDP by 2030.  
Financial resources form the foundation of the innovation system. Armenia's current spending is critically low; scaling it up is necessary to fund laboratories, support researchers, and attract international projects.
2. Strengthen the Innovation Ecosystem.  
Investment alone cannot produce innovation without supportive structures. Clusters that unite universities, businesses, and startups can accelerate knowledge transfer. Policies must also address brain drain by creating incentives for skilled professionals to stay in or return to Armenia.
3. Integrate with Digital Transformation and Green Growth. Global economic dynamics are shaped by digitalization and sustainability. Armenia must embed innovation into these

<sup>4</sup> Composed by the authors.

megatrends by promoting e-government, SME digitalization, and renewable energy solutions. This ensures long-term relevance and competitiveness.

4. Achieve Higher Competitiveness and Sustainable Growth. The ultimate effect of the model is systemic: a stronger position in the Global Innovation Index, increased exports of high-tech goods, and overall resilience of the national economy. Armenia's progress will be measured not only by internal reforms but also by its ability to compete globally.

The analysis confirms that Armenia's innovation system is characterized by chronic underfunding, weak institutions, and high levels of emigration, yet it also has significant untapped potential in STEM education, diaspora engagement, digital startups, and green development. Comparative lessons from Israel, South Korea, and Estonia demonstrate that different models of innovation policy can succeed if properly adapted to national contexts. For Armenia, the key priorities should be to scale up R&D funding, reform governance, and integrate innovation policy with digitalization and sustainability strategies. Without these changes, Armenia risks remaining on the periphery of global innovation; with them, it has the potential to transform into a competitive and resilient economy.

## Conclusion

The conducted study has demonstrated that Armenia's innovation system is characterized by structural weaknesses such as chronic underfunding of R&D, weak institutional capacity, and continuous emigration of highly skilled professionals. At the same time, the country possesses significant untapped potential, rooted in its STEM traditions, diaspora engagement, digital startups, and opportunities for green development. Comparative analysis of Israel, South Korea, and Estonia proves that different models of innovation policy (venture-driven, state-led, or digitally focused) can all succeed when properly adapted to national conditions. Based on the findings, the study proposes a set of priority measures to strengthen Armenia's innovation-driven growth:

- Increase and Stabilize R&D Financing
  - Raise R&D expenditure to at least 1% of GDP by 2030, ensuring predictable, multiyear funding for scientific research, applied development, and high-tech commercialization.
  - Introduce diversified financing mechanisms through the Ministry of Finance, Ministry of High-Tech Industry, Science Committee, and state development funds (e.g., The Enterprise Armenia Investment Fund).
  - Expand competitive grants, innovation vouchers, and co-funding schemes for universities and firms.
  - Potential risk: limited fiscal resources and macroeconomic volatility may hinder sustained funding, while inefficient allocation could reduce impact.
- Strengthen the National Innovation Ecosystem
  - Develop sector-specific innovation clusters (ICT, biotechnology, engineering, creative industries) supported by the Ministry of Economy and regional development programs.
  - Incentivize science–business cooperation, including joint laboratories, technology transfer offices, and intellectual-property support mechanisms.

- Implement policies to retain and attract talent, such as career-development grants, post-doctoral programs, diaspora scientist engagement schemes, and startup-friendly migration policies.
- Potential risk: persistent brain drains, limited institutional coordination, and weak commercialization channels may undermine ecosystem efficiency.
- Integrate Innovation with Digital Transformation and Green Growth
  - Support digitalization of public and private sectors, promote the adoption of AI, big data, cybersecurity, and automation solutions, and expand e-governance platforms.
  - Encourage green technologies through incentives managed by the Ministry of Environment, including renewable-energy innovation, circular-economy solutions, and climate-tech startups.
  - Align national strategies with global innovation megatrends to enhance competitiveness, sustainability, and resilience.
  - Potential risk: insufficient regulatory frameworks for emerging technologies, slow adoption by traditional sectors, and limited green-finance instruments.

In conclusion, Armenia is at a crossroads: maintaining the current trajectory of stagnation or undertaking comprehensive reforms. The proposed conceptual model offers a realistic roadmap for transforming Armenia into a competitive and resilient innovation-driven economy.

#### Conflict of Interest

The author declares no conflicts of interest.

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## STRUCTURAL SHIFT TRENDS IN RUSSIAN AGRI-FOOD EXPORTS

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**Abstract:** This article examines trends in the development of Russia's agri-food exports amid intensifying global economic and technological challenges. The study focuses on long-term structural changes within key export product groups and assesses the role of technological factors in shaping diversification processes in the agri-food sector. Using an analysis of export diversification within competitive product categories of the Russian agri-food complex, the study identifies both general and group-specific trends in the depth and intensity of diversification.

The results reveal a growing specialization of Russian exports in grain crops. Between 2001 and 2019, the share of wheat and meslin in total grain exports increased from 53.01% to 80.78%, indicating a consolidation of comparative advantages in this segment. An analysis of structural break coefficients shows that grain exports are characterized by relatively minor structural changes, reflecting stability in the export structure. At the same time, technological innovations have contributed to diversification in downstream industries. In particular, the introduction of innovative technologies enabled the expansion of exports in the flour-milling industry. Russia began exporting wheat gluten in 2006, and by 2019 its share within this product group had reached 16.04%. The most intensive restructuring of flour and cereal product exports occurred between 2010 and 2014.

The study also highlights the increasing integration of Russian meat and meat product producers into global food markets. Over the study period, the range of exported meat products expanded substantially, and structural change coefficients indicate that export diversification progressed most rapidly in this group. Overall, the adoption of innovative technologies in the agri-food complex has fostered the emergence of new industries and products, reshaping export structures, reducing risks, and enhancing the competitiveness of Russian agricultural producers in global food markets.

**Keywords:** export, structural shifts, trends, food market, agri-food complex

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### Introduction

Changes in the conditions and factors governing the functioning of global and national markets under the influence of globalization processes stimulate the search for new sources of economic growth and the development of effective strategies to enhance competitiveness. The formation of a sustainable long-term economic growth model worldwide is increasingly determined by the expanding role of science, technology, and innovation.

Russia, like many other countries, faces global challenges associated with the emergence of new markets, technologies, and products with novel characteristics, the transformation of

traditional industries, and the accelerated flows of knowledge, technology, capital, and human resources. These technological challenges are further compounded by macroeconomic instability and heightened geopolitical uncertainty.

Under these conditions, a priority direction for enhancing the competitiveness of the Russian agri-food complex in both domestic and international markets is the transition to an innovation-driven stage of development. This transition is based on rapid advances in science and technology, the strengthening of scientific and technological potential, the reduction of innovation implementation cycles, improved access to new technologies for small and medium-sized enterprises, and a shift toward more advanced technological paradigms.

Diversification, as a key factor in improving the competitiveness of the Russian agri-food complex, is of considerable theoretical and practical importance. It contributes to saturating the domestic market with high-quality and affordable food products for all population groups, while also supporting the expansion of foreign economic relations. In recent years, increasing attention in the global academic literature has been devoted to examining the relationship between export concentration and diversification, the interaction between export dynamics and structure and national economic development, and the impact of production and export diversification on GDP growth [1].

The impact of factors such as per capita income, country size, remoteness and market accessibility on the concentration and diversification of exports and production is analyzed [2][3][4]. The development of convergent technologies, which are a synergistic combination of four main areas of science and technology: nano-, bio-, info- and cognitive technologies, has a significant impact on the functioning of the agri-food complex. New technologies are developing rapidly and determine the structure of the economy, its foreign economic relations, the predominance of certain industries [5].

Diversification as one of the country's economic competitive strategies is associated with penetration into new economic sectors and new markets, expanding the range of products, which allows reducing risks, increasing competitiveness and efficiency of resource use, and stabilizing cash flows [6]. For the Russian agri-food complex, the diversification strategy makes it possible to use a unique variety of competitiveness factors and their possible combinations, which makes it possible to effectively balance multiple risks in the global economy and ensure optimal integration into diverse and generally difficult to predict trends in global demand [7].

The aim of the study is to identify trends in structural shifts in Russian agri-food exports and the factors that form them, substantiate promising directions for diversifying agri-food exports based on the implementation of competitive advantages and strengthening competitive positions in traditional Russian segments of the world food market.

## Methodology

The study of the agri-food exports structure makes it possible to determine the priorities of its development, structural aspects of efficiency and competitiveness, the possibility of transformation into a new qualitative state. Assessment of agricultural and food exports as a dynamic economic system requires a comparison of structural changes over time. For these purposes, structural change indices are used. The most common indices are: the H.S. Kazints, K. Gatev, A. Salai and V.M. Ryabtseva.

The linear and quadratic coefficients of absolute structural shifts of Kazinets show how many percentage points on average deviate from each other compared specific weights [8]. The

more the structure changes, the higher the values of the coefficients. The use of the quadratic coefficient is preferable, since it is more sensitive to strong fluctuations in the structure. The integral coefficient of structural changes by K. Gatev and the coefficient of structural differences by A. Salai take into account the intensity of changes in individual groups and the proportion of groups in the compared structures, as well as the number of groups. The Ryabtsev index is the most preferable from the point of view of economic interpretation and allows us to judge the sustainability of the economic system development [9]. It is applied to any set of statistical data, and also has a scale for assessing the significance of structural differences, which allows interpreting the obtained coefficients without using comparative analysis. Its meaning comes down to the ratio of the component's values divergence actual measure of the two structures with their maximum possible value.

The information base for assessing the dynamics and structure of agricultural products and foodstuffs exports in Russia was the Trade Map - International Trade Center (ITC) data on the harmonized system (HS). The available database is represented by data on the volume of exports in thousands of US dollars. The calculations were carried out in current prices; therefore, the results of calculations are affected by the influence of interregional price differentiation.

## Results

The formation of measures system of state regulation and support for the agri-food complex sectors made it possible to increase the competitiveness of national producers in the food market and significantly increase the volume of agricultural products and food exports. The competitive position of Russia in the market of grains and oilseeds, vegetable oil and animal fats has significantly strengthened. The competitiveness of the milling industry products, animal feed, and certain types of animal products has increased [10]. The maximum increase in export volumes is observed in the group of meat and meat products. The export of meat and meat products from Russia from 2001 to 2019 increased 156 times in value terms. Export of grain crops is also characterized by high, but unstable dynamics. The increase in exports for the group of flour-grinding industry products for the analyzed period amounted to 7.9 times.

However, a further increase in export volumes does not give positive effects to the national agri-food complex. The risks of random price fluctuations in the specialization markets of Russian exporters and a sharp drop in demand are growing. The country's specialization in a narrow-limited range of goods, especially raw materials, significantly slows down the development of processing and high-tech industries due to the lack of incentives for such development. Diversification of the commodity structure of Russia's foreign trade is a strategic direction for the development of the country's agri-food complex [11]. Groups of goods characterized by high sales dynamics and competitiveness in foreign markets were selected for the study. The analysis was carried out on the basis of the following groups of goods: cereals, flour and cereals industry, meat and meat products.

From 2001 to 2019, there is a positive trend for all analyzed grain crops. There have been changes in the structure of grain exports (Fig. 1). In 2001, the main exported crops were barley, wheat and meslin. Their share was 97.9% of the total export of grain crops. Corn, rice, buckwheat, millet accounted for 2.1% of grain exports. In 2019, the range of grain crops exported from the country expanded. The share of corn exports increased significantly (from 1.1% to 7.8%). Russian producers began to export oats, rye, grain sorghum. However, during the study period, there has been an increase in Russia's specialization in the grain market. The share of wheat and meslin

increased from 53.01% in 2001 to 80.78% in 2019. The remaining types of grain crops in 2019 accounted for only 19.22% of the Russian producers' export.

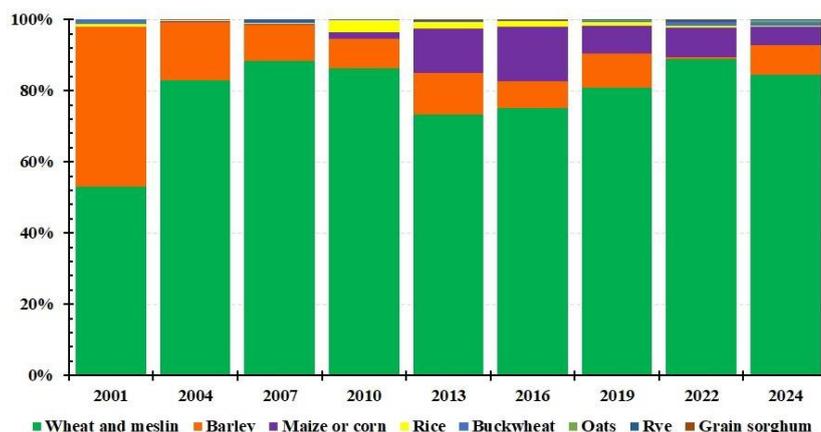


Figure 1. Change in the structure of Russian grain crops exports, %, thousand US dollars

Significant changes during the study period were revealed in the group of flour-and-cereal industry products (Fig. 2). Russian producers were actively exploring new sales markets. In 2001, the main exported product of this group was wheat or wheat-rye flour (75.13%). Other types of products accounted for less than 25.0%. By 2019, the share of wheat and wheat-rye flour decreased to 30.98%. The share of processed cereals and malt in the export structure of this group increased more than 4 times. Since 2006, Russia has been exporting wheat gluten. In 2019, its exports amounted to USD 52.6 million, or 16.04% in the structure of exports of the flour and cereals industry products.

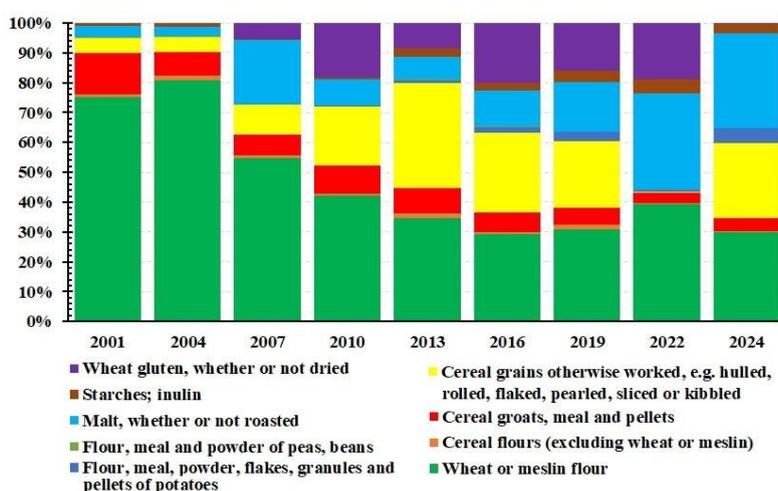


Figure 2. Change in the structure of Russian flour and cereals products exports, in%, thousand US dollars

The production of meat and meat products is one of the most actively developing sectors of the country's agri-food complex, which is explained by the spread of advanced technologies mainly at large enterprises that have the financial capabilities to purchase them. Large agricultural holdings are engaged in the construction of export-oriented farms by introducing large-scale "conveyor" animal husbandry. The implementation of the import substitution strategy and the increase in government support have made it possible to significantly increase the

domestic production of meat and meat products, and increase the country's self-sufficiency. Russian meat and meat products producers are becoming active participants in the global food market [12]. Structural changes took place in the range of exported meat products (Fig. 3). In 2001, Russia exported mainly poultry meat (60.1%) and edible offal and other meat (34.97%). Other types of meat and meat products accounted for less than 5.0%. During the study period, the highest growth rates were observed in the export of poultry and pork meat. Since 2012, the export of lamb and goat meat has been growing. At present, it accounts for 8.93% of the total export of meat products. The share of cattle export increased 2.5 times.

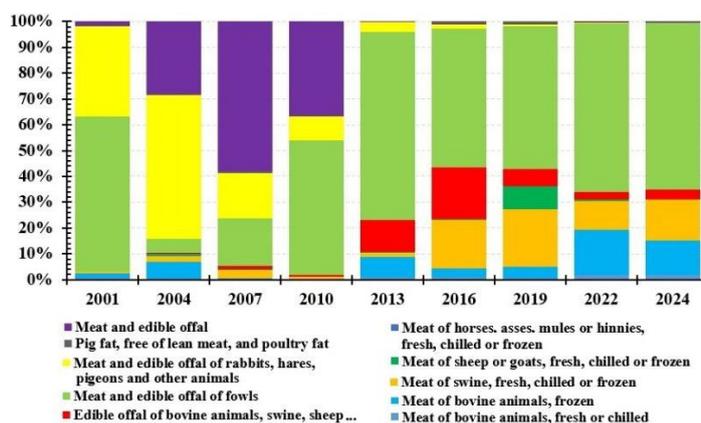


Figure 3. Change in the structure of Russian meat and meat products exports, %, thousand US dollars

The assessment of the structural changes in exports that occurred in the main commodity groups of Russia's agri-food exports was carried out on the basis of a set of universal indicators.

In the group of grain crops during the study period, there is an increase in export specialization. The main manufacturers focused on a significant market with low growth rates from the traditional category, the development of which does not require a large-scale introduction of new technologies and a radical change in consumer preferences.

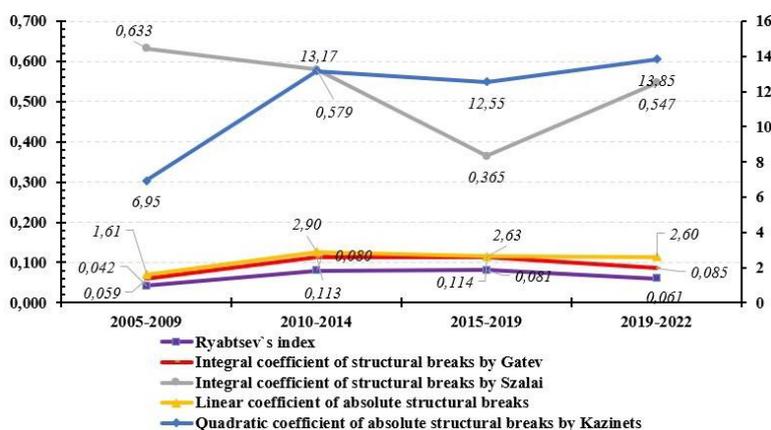


Figure 4. Dynamics of changes in the coefficients of structural shifts in the grain crops export

More complex dynamics were observed in the export structure of flour-milling industry products during the study period (Figure 5). In 2001, Russia exhibited a narrow specialization in the flour and cereal market. Until 2010, wheat and rye-wheat flour constituted the dominant

export products within this group. Between 2010 and 2014, a new export structure began to emerge. The calculated coefficients indicate substantial structural shifts, while the Ryabtsev index reflects a high degree of structural differentiation. Since 2015, a gradual attenuation of structural changes and stabilization of the export structure of Russian flour and cereal products have been observed. Diversification of flour-milling industry exports represents a priority direction for the development of the agri-food complex, as it promotes the expansion of exports of high value-added products.

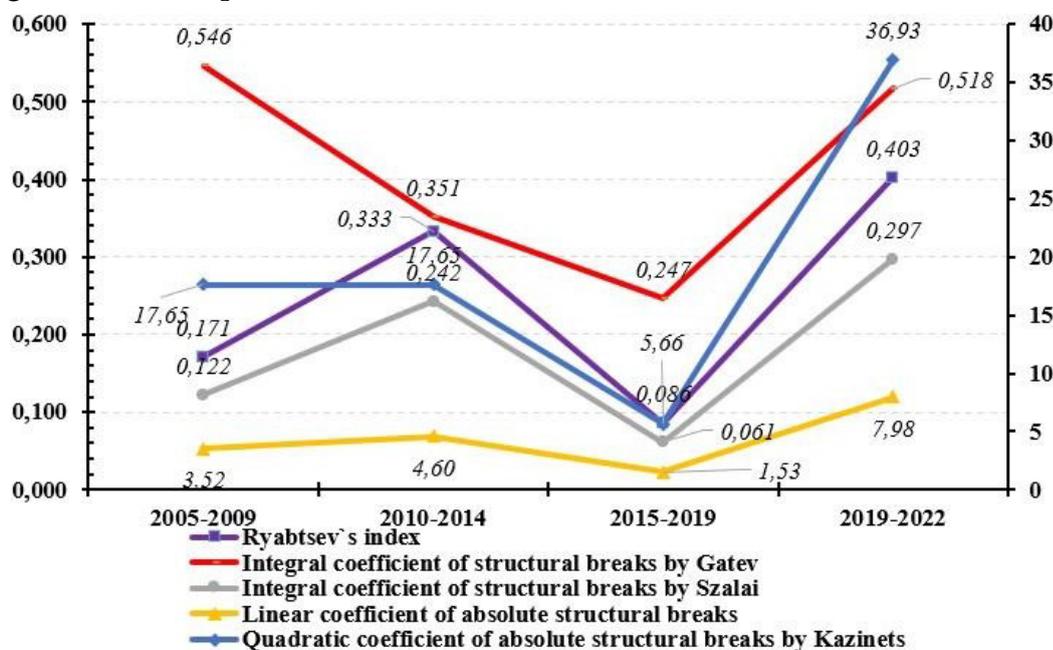


Figure 5. Dynamics of changes in the coefficients of structural changes in the flour and cereals industry products export

The processes of exports commodity structure diversification are the highest in the group of meat and meat products (Fig. 6). However, this group also revealed the features of structural changes. In 2010-2014 in the group of meat and meat products, significant structural changes are observed. In recent years, the structure of meat and meat products exports has stabilized.

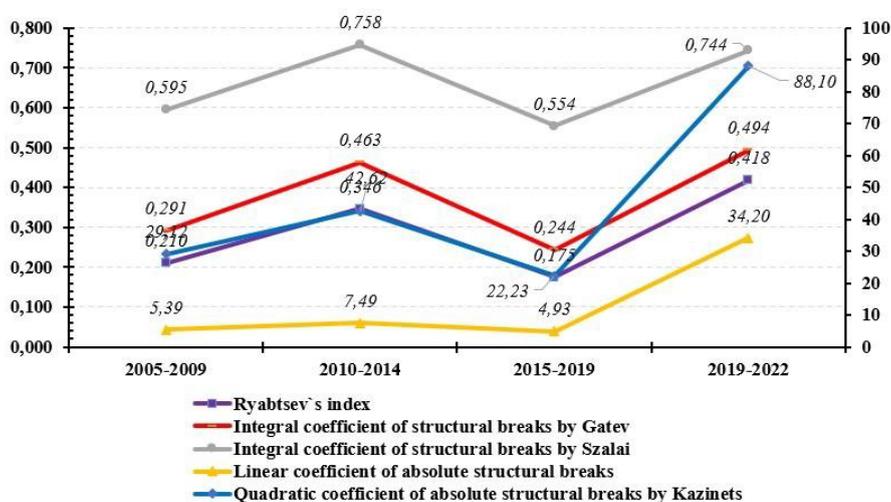


Figure 6. Dynamics of Changes in Structural Shift Coefficients of Meat Products and Edible Meat Offal Exports

The structure of food industry production is characterized by the predominance of products with low level of newness. The share of new products for enterprises, but already known on the markets and improved based on previously produced products is 90%. The priority areas for increasing the competitiveness of the Russian agri-food complex in the global food market should be, on the one hand, the outstripping development of fundamentally new high-tech sectors and markets, and on the other hand, deep technological modernization of traditional industries and manufacturing. The combination of these two areas can ensure the technological modernization of the country's agri-food complex in the medium term, will create new competitive advantages of national producers, strengthen their competitive position in the world food markets.

### Discussion

Russia's principal competitive advantage in the global agricultural and food market lies in the availability of abundant renewable raw material resources. The adoption of innovative technologies at the post-agricultural stages of food value chains, together with the expansion of deep processing of agricultural raw materials, leads to the fragmentation of production chains, enabling the parallelization of production processes and their broader geographical dispersion. Deep processing of agricultural products involves the separation of raw materials into individual components and their efficient utilization in high-value-added products. This approach makes it possible to produce a wide range of outputs used across multiple industries.

For instance, derivatives and bioproducts obtained from grain are applied not only in the food industry but also in petrochemical and related sectors. The development of a grain-based product chain oriented toward innovative technologies would allow a more comprehensive exploitation of regional competitive advantages, including favorable natural and climatic conditions, as well as scientific and industrial capacity, human capital, and developed infrastructure.

Technological challenges also create new opportunities for the development of environmentally friendly food products and next-generation foods with predefined quality characteristics, including specialized, functional, and fortified products. These advances increasingly rely on modern genomic and post-genomic technologies. In addition, the development of organic agriculture, due to the high margins associated with organic products, can support the sustainable development of rural areas and enable the implementation of a more differentiated agricultural policy.

### Conclusion

The diversification of Russia's foreign trade in agricultural products and food represents a complex and multifaceted challenge. Taking into account the internal capabilities of the Russian agri-food complex and the intensification of contradictions arising from globalization, a strategy for diversifying agri-food exports can be pursued simultaneously along two main directions: the development of an innovation-driven model and related diversification within individual product groups.

Diversification processes across product groups are uneven and shaped by a variety of factors. Under favorable conditions in global food markets, grain producers have intensified their specialization in wheat production. However, against the backdrop of domestic market stagnation

and increased price volatility in international markets, such specialization may slow economic growth, reduce financial returns, and heighten production dependence on external conditions. During the same period, enterprises in the flour and cereal industry expanded their export product range by entering new markets for wheat gluten, malt, starch, inulin, and related products.

State support for domestic meat and meat product production has strengthened the foreign economic activity of national producers. This support has not only increased the volume of Russian exports of meat and meat products but has also stimulated diversification processes within the meat segment of the agri-food complex.

Diversification of exports within product groups enables producers to incorporate new goods into export flows without altering their core specialization, thereby preserving competitive positions based on existing comparative advantages. More broadly, the promotion of diversification creates a foundation for stable economic dynamics and medium-term fiscal sustainability, supports the modernization of the production structure of Russia's agri-food complex, and establishes conditions for more dynamic growth in exports of innovative and high value-added products.

#### Conflict of Interest

The authors declare no conflicts of interest.

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# BEYOND DISCLOSURE: EMBEDDING CLIMATE TRANSITION RISK IN FINANCIAL SUPERVISION AND BANKING STRATEGY

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**Abstract:** The paper explores the integration of climate transition risk into the financial supervision of banks, with a particular focus on regulatory evolution and strategic responses to an increasingly stringent sustainability policy environment. As governments advance commitments to net-zero transition pathways, banks face heightened exposure to risks arising from abrupt regulatory adjustments, the potential stranding of carbon-intensive assets, and rapidly shifting investor and client expectations.

The study examines how supervisory authorities, especially within the European Union, are moving beyond disclosure-based approaches to incorporate climate transition risk into prudential supervisory frameworks. It reviews key regulatory instruments, including the European Central Bank's Guide on Climate and Environmental Risks, the European Banking Authority's finalized Guidelines on the Management of Environmental, Social, and Governance Risks, and emerging practices in climate-related stress testing.

Special attention is devoted to the conceptual and methodological challenges associated with assessing transition risk, such as non-linear risk dynamics, scenario design, and the selection of appropriate time horizons. The paper also analyzes how banks are adapting their internal risk management and assessment frameworks in response to supervisory expectations. In addition, it provides insights into the heterogeneity of supervisory implementation across EU Member States and discusses the implications for banking strategy, particularly in the areas of capital planning, risk appetite, and portfolio alignment.

The paper concludes with policy-oriented recommendations aimed at strengthening supervisory convergence and embedding climate transition risk within prudential supervision in a proportionate, forward-looking, and effective manner.

**Keywords:** climate transition risk, prudential supervision, climate stress testing, NGFS scenarios, Climate-Policy Relevant Sectors, prudential transition plans, loan-pricing carbon premium

## Introduction

Climate transition risk refers to the financial consequences of the policy, technology, and market changes required to move the economy toward net-zero greenhouse-gas emissions. For banks, this means that some clients, especially those in carbon-intensive sectors such as energy, steel, or aviation, may face rising costs, declining demand, or asset stranding. Conversely, firms

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investing in low-carbon technologies may gain competitive advantage. The transition is therefore both a risk and an opportunity, but it must be managed within prudential frameworks.

For the past decade, much attention has gone into climate-related financial disclosure frameworks (such as the Task Force on Climate-related Financial Disclosures and its successor, the IFRS International Sustainability Standards Board. These have improved transparency but have not guaranteed that banks' strategies or supervisors' assessments change accordingly. As the Basel Committee on Banking Supervision notes, climate change poses "unique and significant challenges to the banking system," and supervisors should ensure that risks are identified, measured, and managed, not merely disclosed [1].

The European Central Bank has led in practice: it issued its Guide on Climate-Related and Environmental Risks. Supervisory Expectations Relating to Risk Management and Disclosure and then it ran an economy-wide climate stress test in 2021 and a banking-sector stress test in 2022, both of which showed that early action reduces losses, but also that banks' capabilities were inadequate [2]. The European Banking Authority in 2025 published Final Guidelines on ESG risks under the Capital Requirements Directive VI, requiring banks to prepare prudential transition plans, that is, forward-looking, risk-based strategies for managing climate transition risks as part of their capital and governance processes [3].

We argue that supervisors and banks should build on disclosure and move "beyond" it by using Climate-Policy Relevant Sectors sector mapping and NGFS scenarios to systematically embed transition risk in their strategies, risk assessments, and supervisory dialogues. This article sheds light on the concepts in and demonstrates how they can be used without advanced quantitative modeling.

### Literature Review

The recognition that climate change poses systemic risks to finance began with The Green Swan report by the Bank for International Settlements and Banque de France, which described climate change as a "potential source of the next systemic financial crisis" because of its radical uncertainty and longtime horizons [4]. Early academic work such as Battiston et al. demonstrated that financial networks could amplify the impact of climate policy shocks, creating contagion effects through portfolios of carbon-intensive assets. Carney, in his "Tragedy of the Horizon" speech, similarly argued that short planning horizons in finance clash with the long-term nature of climate risks.

The Basel Committee on Banking Supervision in 2022 codified this recognition by publishing 18 principles for banks and supervisors on climate risk management [5]. These principles emphasize governance, risk identification, scenario analysis, and supervisory review. The European Central Bank followed with an economy-wide climate stress test in 2021 and a dedicated supervisory stress test in 2022 [6], both of which showed that banks with more carbon-intensive portfolios face higher credit losses. The ECB's thematic review highlighted persistent gaps in data and methodologies, requiring remediation. The Bank of England's Climate Biennial Exploratory Scenario tested banks and insurers against orderly, disorderly, and "no additional action" scenarios, concluding that early, orderly transition reduces overall losses. The Federal Reserve's 2023–24 Pilot Climate Scenario Analysis marked the first US supervisory exercise, focused on learning about practices rather than setting capital requirements.

The Network for Greening the Financial System has become the global standard-setter for climate scenarios. Since 2018, NGFS has released iterative scenario sets, drawing on Integrated

Assessment Models such as REMIND-MAgPIE, MESSAGE-GLOBIOM, GCAM, and IMAGE [7]. The Phase V scenarios (2024/25) revised key parameters: orderly decarbonization requires a higher carbon price trajectory (around \$300 per ton of CO<sub>2</sub> by 2035) and chronic physical damages are projected at two to four times higher than earlier versions [8]. The short-term NGFS scenarios (2025–2030), released in May 2025, added narratives specifically designed for financial-stability planning horizons, including sudden policy tightening (“Sudden Wake-up Call”) and compound hazard events (“Disasters & Policy Stagnation”) [9]. These scenarios provide explicit GDP, unemployment, and carbon-price anchors for near-term prudential planning.

A challenge for banks is mapping financial exposures to scenario variables. Battiston et al. proposed the taxonomy of CPRS, later refined into granular mappings that connect NACE industrial codes to IAM variables [10]. This allows banks to identify which sectors, such as fossil fuels, utilities, transport, and heavy industry, are most exposed to transition policies, and to apply scenario shocks consistently. Supervisory bodies such as the ECB, EBA, and EIOPA have incorporated CPRS into pilots, emphasizing its comparability and reproducibility [11].

Empirical studies confirm that markets are beginning to internalize transition risks. Altavilla et al. find that euro-area banks charge higher loan spreads to high-emission firms and lower spreads to those with credible decarbonization commitments, consistent with a “climate risk-taking channel” in monetary policy transmission [12]. Delis et al. similarly show that syndicated loan markets penalize carbon-intensive borrowers [13]. Krueger, Sautner, & Starks report from surveys that institutional investors already incorporate climate risk into portfolio decisions. Bolton & Kacperczyk find that firms with higher carbon emissions face higher cost of capital, especially in countries with stronger climate policies.

The development of disclosure and alignment frameworks underpins supervisory and market action. The International Sustainability Standards Board issued IFRS S2 in June 2023, consolidating climate disclosure requirements around governance, risk management, metrics, and transition plans [14]. The Partnership for Carbon Accounting Financials provides a Global GHG Accounting and Reporting Standard for calculating financed emissions. The Paris Agreement Capital Transition Assessment offers a methodology for measuring whether portfolios align with Paris-compatible technology pathways [15]. These tools are increasingly referenced by supervisors, ensuring consistency between disclosure and prudential analysis.

A growing emphasis is placed on the credibility of firms’ transition plans. The Science Based Targets initiative validates whether corporate emission-reduction targets are consistent with 1.5 °C pathways [16]. SBTi validates corporate GHG-reduction targets against climate science. Companies commit to cut emissions by a specific percentage (often 30-50% by 2030) in line with a 1.5 °C pathway. For banks, SBTi-style commitments provide signals that can reduce risk assessments under transition scenarios [17]. Bolton et al. argue that credible transition plans are critical for capital allocation decisions and financial stability.

The literature converges on three points:

- climate transition risks are real and material for banks and financial stability,
- supervisors have established principles and are building tools (scenarios, CPRS, disclosure standards) to embed them,
- empirical evidence shows that markets are already differentiating firms by emissions intensity and transition credibility.

The challenge now is to integrate these insights into prudential supervision and banking



## Methodology

Our methodological approach is intentionally simple and practice-oriented, focusing on steps that can be realistically implemented by banks and supervisory authorities. The analysis begins with mapping bank exposures using Climate Policy-Relevant Sectors (CPRS), which enables institutions to classify all portfolio exposures into transition-relevant categories. Compared with standard industry classifications, this approach provides greater granularity by recognizing that activities within the same broad sector are not equally exposed to transition risk. For example, carbon-intensive activities such as steel and cement production face substantially higher transition risks than less emission-intensive activities such as textiles. Applying the CPRS framework allows policy and technology scenarios developed by the Network for Greening the Financial System (NGFS) to be directly linked to specific portfolio segments, thereby providing a clear and transparent assessment of banks' exposure to transition-sensitive economic activities.

The second step involves the use of NGFS scenarios, combining short-term and long-term perspectives to capture different dimensions of climate-related risk. Short-term NGFS scenarios for the period 2025-2030 are used to assess banks' resilience to near-term economic and policy shocks, including scenarios characterized by compounding physical events and weak policy responses, orderly and gradual policy tightening, delayed but abrupt regulatory action, and divergent transition pathways across regions. These scenarios generate differentiated impacts on economic growth, employment, and sectoral performance that are directly relevant for credit risk assessment. In parallel, Phase V long-term NGFS scenarios, extending to 2050 and beyond, are employed to evaluate the cumulative effects of alternative transition pathways. These scenarios highlight that early and orderly transitions are less costly over time, whereas delayed action requires steeper carbon pricing and is associated with significantly higher physical damages.

To translate scenario narratives into actionable risk insights, the analysis relies on a structured qualitative interpretation focused on macroeconomic conditions, policy and price signals, and physical risk impacts. Scenarios with weaker growth or higher unemployment imply elevated credit risk in affected sectors, while sharp increases in carbon prices or regulatory stringency raise cost pressures for high-emission activities. Physical hazard scenarios are interpreted in terms of potential declines in collateral values, particularly in agriculture and real estate. These insights can be operationalized through qualitative risk classifications or simple adjustments to default probabilities, with the emphasis placed not on numerical precision, but on the internal consistency of the framework supporting risk appetite decisions and supervisory dialogue.

## Analysis

This section translates the methodological elements, Climate-Policy Relevant Sectors mapping and Network for Greening the Financial System scenarios, into portfolio-relevant insights. The discussion proceeds from exposure diagnostics (Figure 1), to the transmission of short-term scenario narratives into expected losses (Figure 2), and finally to the observed

differentiation in loan pricing by emissions intensity and transition-plan credibility (Figure 3). Throughout, the magnitudes used in the figures are illustrative but aligned with the NGFS anchors described earlier, so that the mechanics is evident without recourse to formal estimation. Figure 1 reports an illustrative CPRS decomposition of a universal bank’s corporate book (shares of total corporate exposure) [18][19][20]. The distribution highlights the concentration of transition-sensitive exposures in a small set of sectors.

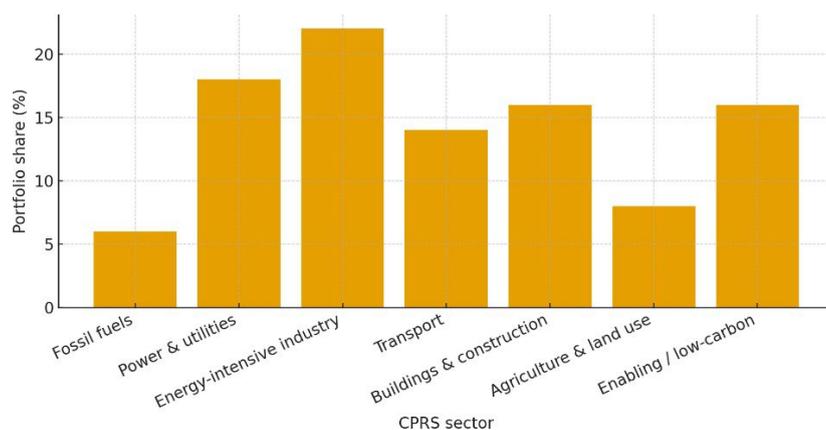


Figure 1. Illustrative CPRS exposures by sector (%)

“Energy-intensive industry” (e.g., steel, cement, basic chemicals, paper) and “power & utilities” generally constitute sizeable portions of corporate lending and are directly exposed to carbon-price trajectories, technology substitution (electrification, green hydrogen, CCS), and efficiency standards. “Fossil fuels,” although typically smaller in nominal share, can be disproportionately vulnerable because of stranding risk under abrupt policy tightening or accelerated demand shifts. “Transport” embeds multiple transition channels (fuel costs, fleet renewal, modal shifts, regulatory coverage), while “buildings & construction” reflects policy effects through building codes, embodied-carbon rules and, in some geographies, exposure to climate-policy-driven changes in planning and permitting. “Agriculture & land use” exhibits a dual sensitivity: transition exposures (methane, fertilizer standards, land-use rules) and physical-risk channels (heat, drought, floods) that can impair collateral and business continuity. Finally, the “enabling/low-carbon” slice (grid reinforcement, renewables, energy-efficiency retrofits) points to opportunities that counterbalance risks elsewhere.

The key analytical implication is that portfolio-level averages obscure heterogeneous risk. CPRS mapping offers a reproducible way to identify where transition forces are most likely to affect cash-flows, default risk, and collateral values. It also supports the setting of sector-specific risk-appetite limits and the monitoring of exposure migration over time, which is relevant for supervisory benchmarking under the European Central Bank and European Banking Authority frameworks discussed earlier.

Figure 2 links the short-term NGFS scenarios (2025–2030) to a single portfolio metric by plotting the 2030 GDP deviation against an illustrative expected-loss add-on (basis points). This representation condenses the scenario narratives into a tractable supervisory and managerial lens while remaining consistent with the NGFS macro anchors [21][22][23][24][25][26].

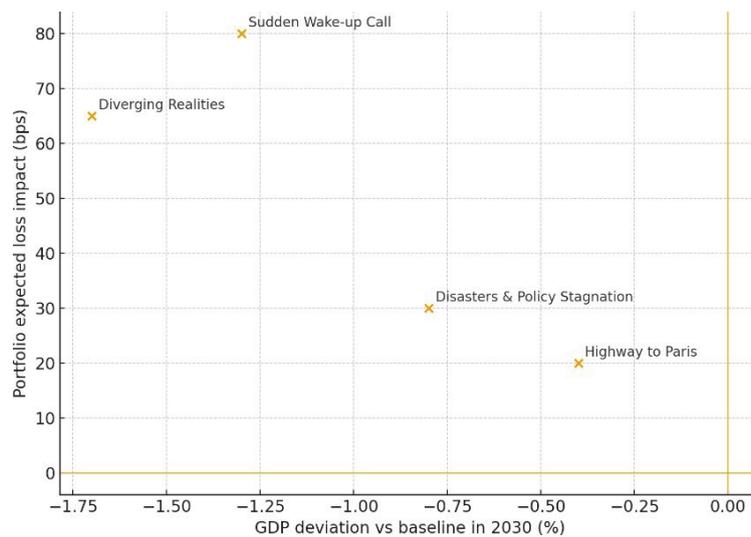


Figure 2. Scenario GDP deviation (2030) vs expected loss impact (bps)

Under Highway to Paris, policy tightens early and gradually; global activity is slightly below baseline by 2030 (around -0.4 percent). In such a path, aggregate losses are modest and largely concentrated in CPRS-high buckets where carbon-price pass-through is strongest, with the distribution further moderated by firm-level transition-plan credibility. In Sudden Wake-up Call, policy is delayed and then tightened abruptly in 2027; the one-year shock ( $\approx -1.2$  percent global GDP with higher unemployment) translates into the largest expected losses increment among the four cases, as both macro and cost channels intensify before firms have fully adapted. Disasters & Policy Stagnation combines compound physical hazards with policy inertia; although the 2030 macro gap is less pronounced than in a disorderly transition, EL rises because loss-given-default increases where collateral is damaged or rendered less productive, and because supply-chain disruptions transmit shocks across sectors and borders. Diverging Realities mixes transition in advanced economies with repeated hazards and supply frictions elsewhere; by 2030 the European Union gap (around -1.7 percent relative to baseline) implies a material EL add-on with geographically uneven incidence across the portfolio.

Expressing scenarios in EL space facilitates consistent translation into pricing add-ons, limit usage, and capital buffers using an institution’s internal conversion factors. The comparative positioning of the four points makes clear that orderly transition is manageable, abrupt policy yields the sharpest near-term impact, physical sequences elevate loss given default and introduce temporal lumpiness, and regional divergence complicates cross-border portfolio steering. Figure 3 presents an illustrative loan-spread add-on by borrower emissions-intensity quartile, separately for firms without and with SBTi-validated targets [28][29][30][31][32][33].

The spread increases with emissions intensity in both cases, but the slope is noticeably steeper for firms that lack validated transition plans. This pattern is consistent with loan-level evidence for the euro area and aligns with the growing supervisory emphasis on prudential transition planning. From a risk-management perspective, borrowers that combine high emissions with credible, time-bound, and capex-backed transition plans exhibit lower sensitivity to transition shocks. Consequently, they warrant a smaller pricing add-on than otherwise comparable borrowers that do not demonstrate such commitments.

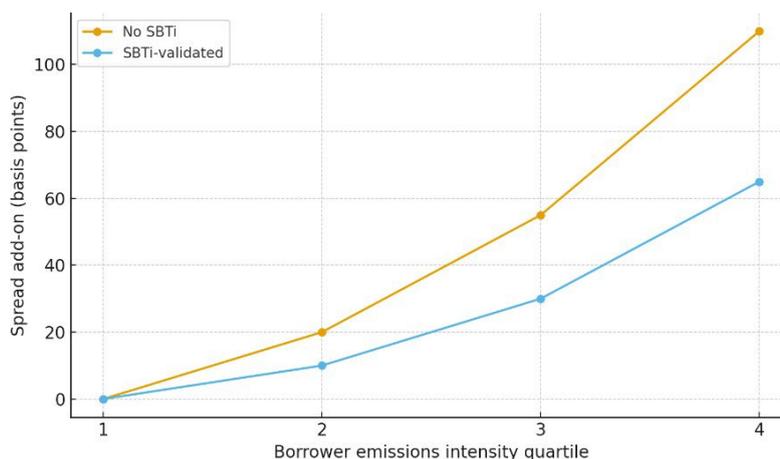


Figure 3. Illustrative loan pricing carbon premium (bps)

Linking Figure 3 to the CPRS framework clarifies the interaction between sectoral exposure and borrower-level heterogeneity. In CPRS-high categories, such as fossil fuels, power and utilities, and energy-intensive industries, the pricing gradient with respect to emissions intensity is generally steeper, and the benefit associated with credible transition plans is more pronounced. In lower-exposure categories, the gradient is flatter, although firm-specific physical-risk profiles and positions within supply chains can still generate meaningful differentiation. This provides a coherent rationale for sector-specific pricing grids and client-engagement priorities that align origination capacity with credible transition trajectories. Taken together, the three figures convey a consistent message. CPRS mapping identifies where transition sensitivity is concentrated on bank balance sheets; short-term NGFS scenarios offer a disciplined way to translate macroeconomic, policy, and physical-risk narratives into expected losses over supervisory horizons; and market pricing already differentiates borrowers by emissions intensity and transition-plan credibility in a manner consistent with these narratives. Collectively, these elements support the supervisory shift toward prudential transition plans under Capital Requirements Directive VI and the incorporation of NGFS short-term scenarios into the Supervisory Review and Evaluation Process. They also provide banks with a transparent basis for setting sector limits, calibrating pricing add-ons, and prioritizing client engagement and transition-finance allocation.

Although the figures are primarily illustrative, the approach is generalizable. Institutions should clearly document how scenario variables, such as activity levels, unemployment, energy and commodity prices, shadow carbon prices, and hazard indicators, are mapped to credit-risk and valuation outcomes, and subject this mapping to robust model-risk governance, including conservative margins where parameter uncertainty is material. Data lineage from counterparties to NACE codes, CPRS categories, emissions metrics (e.g., PCAF), and transition-plan metadata should be auditable, particularly when results feed into the Internal Capital Adequacy Assessment Process and Pillar 3 disclosures. Where possible, qualitative scenario classifications (low/medium/high) can be complemented with interval estimates to reflect uncertainty and avoid spurious precision.

Three conclusions emerge. First, transition risk is not diffuse but sectorally concentrated, making a CPRS lens essential for decision-useful measurement. Second, short-term climate scenarios already generate financially meaningful changes in expected losses, especially under

abrupt policy shifts or compound physical events, underscoring the prudential relevance of NGFS short-term narratives. Third, observed pricing differentials by emissions intensity and transition-plan credibility are aligned with supervisory expectations, providing market-based validation of the analytical framework. Integrating these components enables coherent supervisory dialogue and practical portfolio steering without reliance on opaque or excessively complex models.

### Conclusions and Policy Implications

Supervisory authorities should first establish a common data language to ensure comparability of climate-related risks across institutions. A practical approach is to anchor regulatory reporting in NACE activity codes and the Climate-Policy Relevant Sectors (CPRS) taxonomy, complemented by emissions metrics aligned with the Partnership for Carbon Accounting Financials (PCAF) standard. Each counterparty should be traceable through an auditable sequence from internal identifiers to NACE codes, CPRS categories, and, where available, financed-emissions indicators and transition-plan attributes. Simple data-quality flags explaining missing or estimated data can materially improve reliability without imposing excessive reporting burdens. This shared data infrastructure supports horizontal supervisory reviews, peer comparisons, and consistent feedback within the SREP framework.

Supervisors should then define a scenario policy that combines short-term and long-term NGFS scenarios. Short-term scenarios for 2025-2030 are well suited for near-horizon solvency and liquidity assessments, as they capture policy shocks and physical hazards likely to materialize within supervisory timeframes. Long-term NGFS Phase V scenarios should inform business-model assessment and strategic planning by illustrating the cumulative costs of delayed versus orderly transitions. To enhance transparency and limit model risk, supervisors may publish a concise scenario package specifying a minimum set of macro-financial variables, such as economic activity, unemployment, energy prices, carbon-price proxies, and physical hazard indicators, and require banks to document their transmission into credit risk, asset valuation, and capital adequacy. A key step beyond disclosure is the prudential transition plan required under the Capital Requirements Directive VI and the EBA's ESG risk management guidelines. Supervisors should emphasize that these plans are risk-management tools rather than communication exercises. Each plan should set out baseline exposures by CPRS category and geography, define time-bound steering targets for high-risk segments, and explain how financing strategies support transition objectives. Plans should also specify contingent management actions under adverse short-term NGFS scenarios, including pricing adjustments, exposure limits, and capital-preservation measures. Introducing an evidence-of-use requirement can strengthen effectiveness by demonstrating how transition-risk analysis influences pricing and portfolio decisions.

In Pillar 2 supervision, authorities should prioritize capability- and risk-based measures rather than automatic capital add-ons. Where banks show robust data traceability, consistent scenario use, and clear links between analysis and decisions, qualitative measures and remediation timelines may suffice. Where deficiencies persist, such as missing CPRS mapping or weak governance over assumptions, supervisors should define explicit remediation milestones and escalate if needed. The objective is not to penalize carbon-intensive activities per se, but to ensure that foreseeable risks are managed with the same rigor as other material financial risks.

Given the reliance on new data and judgment-based assumptions, model-risk management is essential. Banks should document key assumptions and margins of conservatism, while avoiding spurious precision. Supervisory reviews may include sensitivity analyses or

challenger assessments, particularly where third-party tools are used. Proportionality remains central. Smaller banks should apply the same principles using simplified tools. Supervisors can support this by facilitating shared utilities, standardized CPRS mappings, common hazard indicators, and clear guidance on the use of NGFS scenarios. Banks should embed transition risk firmly within governance frameworks. Boards should approve a clear transition-risk appetite aligned with the business model, while management should ensure that scenario analysis informs pricing, exposure limits, and capital planning. A pragmatic data strategy, mapping counterparties to NACE and CPRS categories and progressively calculating financed emissions, should be complemented by qualitative assessments of counterparties' transition plans.

Overall, coherence across data, scenarios, governance, and supervisory processes is critical. A structured and transparent approach to transition-risk integration can enhance supervisory dialogue, improve portfolio steering, and support an orderly transition of the real economy.

#### Conflict of Interest

The author declares no conflicts of interest.

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