DOI: 10.55643/fcaptp.6.47.2022.3917

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Received: 10/11/2022
Accepted: 18/12/2022
Published: 30/12/2022

CIRCULAR ECONOMY AND SOURCES OF FUNDING FOR SCIENTIFIC AND TECHNOLOGICAL CLUSTERS

ABSTRACT

In the article from the standpoint of sustainable economic development, the introduction of circular economy principles into production activity is considered. A study of relevant publications was carried out, which reflected the latest achievements of science and practice of the leading countries of America, Europe, and Asia, and a typology of circular economy research was compiled. The author's feature of the typology is proposed - the search for directions for the formation and development of a scientific and technological cluster. As a means of implementing circular economy programs, projects, measures, the definition and formation of funding sources for scientific and technological clusters are proposed.

The problem of financing research and development in Ukraine in comparison with the countries of Europe, North America and Asia was examined, which showed the impossibility of correcting the situation with the help of budget funding in the coming years. Based on the results of the analysis of the specific weight of research and development costs in relation to GDP, a low level of funding for this area of activity in Ukraine was revealed. The need to involve business circles in the financing of research and development requires the use of such an organizational form of work as technoparks. Taking into account the European integration processes and the world experience of creating technology parks with the participation of universities, or territorially separated structures, as well as existing technology parks in Ukraine, it is proposed to form scientific and technological clusters. Scientific and technological clusters should include technoparks, universities, institutes of the National Academy of Sciences of Ukraine, design and technological structures (institutes, bureaus), and production enterprises. This will allow the most effective use of scientific and engineering potential and production capacity under the matrix system of managing all types of cluster resources in the current conditions.

The article proposes the use of methods of analysis, analogy, comparison, induction, statistical, which allowed to thoroughly study the range of issues and draw the appropriate conclusions.

Keywords: circular economy, scientific and technological cluster, research methodology, diversified enterprises, circular economy of the region, research and development funding, filling the scientific and technological cluster

JEL Classification: G38, H72, O33, O57

INTRODUCTION

Ukraine's transition to a model of sustainable economic development involves the development and implementation of the necessary programs, projects, and measures. Making the transition from a linear to a circular economy within the framework of sustainable development is extremely important for Ukraine. The need for such a transition is determined by the course of the Ukrainian state towards European integration, obligations to comply with environmental norms of conducting business in accordance with international agreements, and the desire to raise the social and economic standards of life of Ukrainians.

Our research should reveal certain problems, to answer a number of questions through the implementation of a certain set of tasks. Such tasks are the research of publications on issues of sustainable development and circular economy; determination of features of research typology and possible means of implementation of circular economy programs, projects and measures; study of the problem of financing research and development in Ukraine in comparison with the countries of Europe, North America and Asia; justification of the need to create scientific and technological clusters in modern conditions in Ukraine; determination of the place and role of technoparks in science and technology clusters.

LITERATURE REVIEW

Global changes in the climate of the planet caused the need to review economic activity in all sectors. Industry, agriculture and other types of economic activity affect all components of the environment through emissions. If the produced products are needed by people, then gas emissions, sewage, and solid waste spoil the environment and even make it unsuitable for the normal existence of both people and animals and plants. Thus, there was a need to revise technological processes, to turn to the reuse of resources used for the production of already consumed products. A lot of research has been done on this topic in recent decades. Including research with the defense of dissertations conducted by Ukrainian scientists. The researchers studied various aspects of environmental protection. It is important to study general approaches to motivating a wide range of participants in economic activity regarding sustainable low-carbon development [1]. The use of renewable energy sources is a universally recognized way of sustainable development. The expediency of implementing projects in this direction is emphasized in works [2, 3]. The author of the study [4] connects the economic and, in particular, the energy policy of Ukraine with the need for European integration. The specified direction of Ukraine's cooperation with the European Union is desirable not only for the protection of the natural environment but also for the economic growth of the state, and for the technological renewal of domestic enterprises. Of course, such cooperation involves not only portfolio but primarily direct investments.

There are quite a lot of pieces of evidence on the topic of environmental protection, which show the participation of the Ukrainian state in global programs and projects for the implementation of sustainable development. Such evidence is relevant to analytical materials [5] and scientific articles [6]. Also, an important aspect of solving environmental problems is the participation in this process of the citizens of the country, the entire society, as the authors of the publication write about [7]. At the same time, it is emphasized the need to harmonize the national policy with the relevant programs of the Eastern Partnership countries.

The issues of sustainable development and environmental protection have acquired new features over a long period of time. Details of individual problems are taking place, and new directions for the implementation of specific projects are being formed. Scientists and practitioners, including government officials of leading countries, as well as international organizations, have reached a conclusion regarding the adoption of a new paradigm for the implementation of production activities, which was formulated as a «circular economy". In recent years, the work of foreign researchers [8, 9, 10] has become important work of a conceptual nature regarding the circular economy. Ukrainian scientists also study the peculiarities of the implementation of conceptual foundations of the circular economy in our country. The analysis of the studied trends is extremely important for determining the prospects of the Ukrainian economy in the conditions of the country's expected joining the European Union [11]. At the same time, it is extremely important to effectively use international experience in the transition from a linear to a circular economy in Ukraine [12]. It is necessary to implement and develop waste-free technologies in every possible way [13]. Perhaps this should be considered the first condition for the implementation of the circular economy. An important aspect of the implementation of circular economy ideas in practical activities is logistics, which the author of the article writes about [14].

The paradigm of the circular economy was, of course, first of all, formulated at the international level and was subsequently considered at the level of the macroeconomics of individual countries. State regulation of the circular economy implementation process was and remains an important direction of state management in the economic sphere [15]. However, the key goal of the circular economy was and remains the restructuring of activities at the micro level, directly at enterprises that used and continue to use environmentally harmful technologies. Of course, appropriate business models should be developed and implemented for enterprises [16]. An important step in the process of implementing the principles of the circular economy into the practice of production activities is the development of circular business models, which is detailed in the publication [17]. After all, it is common knowledge how expensive the projects of treatment facilities are. The support of state bodies, specialized domestic and international organizations, and foundations is definitely needed. The capabilities of industrial enterprises are quite limited [18].

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In the future, the specified paradigm began to be considered and implemented through appropriate organizational and technological measures at the meso level. In particular, certain programs are developed at the level of individual territories. The authors of the article [19] write about their expediency and advantages. Such programs exist in the Lviv region [20], Khmelnytskyi region [21], and Volyn region [22].

Separately, it should be said about the role of clusters in the implementation of the circular economy - a number of enterprises and organizations that are united by technological connections or have similar technological processes. The authors of the study [23] are convinced of the decisive role of clusters in the development of the circular economy. Clusters as means of ensuring strategic management of machine-building enterprises are studied in [24]. The example of the Baltic countries shows the influence of clusters on the development of small and medium-sized enterprises with the effective implementation of innovative circular cycle technologies. Researchers of clustering in the Scandinavian countries are also convinced of the effectiveness of the functioning of clusters. The positive impact of clusters on agriculture, tourism, and others is proven [25].

The implementation of programs and projects of the circular economy through digitalization is necessary in modern conditions. This is written by foreign researchers [26,27] and Ukrainian scientists [28].

The researched publications highlight mainly the results of research of recent years. Of course, it is not possible to cover all publications over a longer period of time in one article. Instead, these publications cover the results of research from previous years, which can be considered quite acceptable for our study. These publications allow us to draw a conclusion about the problem, which has not yet found sufficient coverage.

AIMS AND OBJECTIVES

Such a problem is the formation of scientific and technological clusters for the implementation of the principles of the circular economy and investment in such clusters.

The results of the study will be taught in such a sequence. First, on the basis of the mentioned publications, we will formulate the characteristics of the research typology and determine the possible means of implementing circular economy programs, projects, and measures. Next, we will consider the problem of financing research and development in Ukraine in comparison with the countries of Europe, North America and Asia. Finally, we will show the place and role of technoparks in science and technology clusters.

METHODS

The methodological and source base of the study are international documents, recommendations of international congresses and conferences on climate change and environmental protection. Also, research materials are based on domestic regulatory and legislative acts, on publications of foreign and Ukrainian researchers of climate change and ecology problems, and on circular economy abroad and in Ukraine.

The research methodology is based on the comparison of research results, and recommendations of foreign and Ukrainian scientists and practitioners. This approach is necessary for determining the author's positions on the problems of the circular economy, the place of scientific and technological clusters in these problems. The method of analogy and the inductive method were used to substantiate the transfer from various approaches to the circular economy to the ones proposed by us: signs of the typology of research directions and to the means of implementing programs, projects, and measures of the circular economy, the formation and use of a scientific and technological cluster with the participation of universities, institutes of the National Academy of Sciences of Ukraine, design and technological organizations, production enterprises.

Also, the comparison method is used to assess the degree of sufficiency of financial resources for conducting research and designing developments. This issue is considered for the Ukrainian economy in comparison with the economies of other countries. The statistical method and the method of analysis made it possible to reveal certain peculiarities in the dynamics of the indicator of research and development expenses. According to the results of the analysis of this indicator in Ukraine, its downward dynamics was revealed, which is a negative phenomenon that should be overcome.

RESULTS

The study and comparison of the results of the research of foreign and Ukrainian scientists in the field of sustainable development and the deepening of this direction of science within the framework of the circular economy allow us to make certain generalizations. In particular, it is possible to identify certain already sufficiently researched problems and, what is even more important, to indicate such areas of scientific and practical activity that are insufficiently covered in publications. Obviously, the lack of publications indicates not only the small number of studies in certain directions. Insufficient attention to the problem on the part of scientists is to some extent a reflection of shortcomings in practical activities. To better understand the prospects for further research, it is necessary to identify certain features of typology, on which the problems of the circular economy have already been sufficiently studied, and on which there are still some outstanding issues. For the convenience of determining the specified aspects of our research, we will summarize the results of the study of literary sources in Table 1. At the same time, we will use an analogy from mathematics, where the dependence between «argument» and «function" is considered. It is the comparison of ideas and conclusions of different authors, which can be conditionally considered as certain «arguments", that give grounds for formulating such generalizing features, which could be conditionally considered as «functions». In other words, we use the inductive method of research, moving from a certain amount of specific cases to a generalization. It is in this way that we build a table, first naming the researched publications and their content (formulated according to our vision of the problems), and then as derivatives, we define the characteristics by which the researched results can be grouped. An important point in such an explanation is, along with the definition of the features of the typology, a proposal for possible means of implementing circular economy programs, projects and measures.

Table 1. Typology of circular economy research.

Publications		We have proposed a typology of the research direction	Means of implementation of circular economy programs, projects, measures
No. according to the list of used sources	**Generalized conclusion regarding the direction of the content of the publication (according to our author's approach)**		
1	**2**	**3**	**4**
1,2,3	Motivating participants in economic activity regarding sustainable development and the use of renewable energy sources and other resources.	The search for a global way to achieve the goals of sustainable development	Implementation of the «circular economy» paradigm in the field of scientific research and the practice of state economic management
8,9,10	The new paradigm of the implementation of production activity is the «circular economy».	Formulation of a new paradigm for the implementation of production activities	
4.5.6,7	The connection between the economic policy of Ukraine and the need for European integration and the participation of the whole society in this process.	The search for means of joining Ukraine to the global path of achieving the goals of sustainable development	
11,12,13	The use of international experience in the transition from a linear to a circular economy in Ukraine.		
14	The need for state regulation of the circular economy implementation process as a component of state management of the economic sphere.		
18,19,20,21	Introduction of the circular economy paradigm at the meso level, at the level of individual territories.		
15,16,17	Reorganization of activities at the micro level (at enterprises, in scientific and technological organizations) as a goal of implementing the circular economy.	The search for means of implementing the principles of the circular economy on the micro level	Implementation of the «circular economy» paradigm in the field of scientific research and the practice of production activities of enterprises and organizations
22, 23	The role of clusters in the development of the circular economy		
24,25,26	Digitalization of the economy according to the circular model.		
Current author's research	Integrating the views of previous researchers	The search for directions for the formation and development of a scientific and technological cluster	Determination and formation of funding sources for scientific and technological clusters

The implementation of large national or regional programs, projects or activities of individual enterprises requires financial support. Implementing a circular economy requires a lot of resources. After all, it is necessary to change the composition of the equipment, review the terms of the material support of enterprises, conclude new agreements with suppliers, and conduct retraining of personnel. Such sets of measures require extensive organizational work with all counterparties. First of all, there is a need to agree with consumers of products and services regarding new regulations, standards, and technical conditions of production. The consumer needs to prove the feasibility of producing products and/or services from used

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materials. At the same time, in some cases, when the issue concerns structural elements for the production of vehicles, lifting and transporting machines and mechanisms, construction structures, it is necessary not only to approve but also to conduct preliminary tests to ensure the safety conditions of future objects and/or means. The mentioned factors cause quite a lot of problems related to additional expenses. Without sufficient financial support, the transition from a linear to a circular economy is impossible. Of course, the adequacy of funding depends primarily on state policy. Undoubtedly, a market economy is an economy based on private property, on the initiative of entrepreneurs. Instead, such an initiative can be effective only with appropriate state support. State support for business is in the relevant legislative norms, in the creation of a favorable investment climate. It can be considered that the reflection of the state's favorable attitude to certain economic changes is a sufficient amount of costs for conducting research and designing developments. To analyze the Ukrainian economic situation from this point of view, we will provide relevant data from other countries. Comparing the costs related to research and development in Ukraine with other countries, you can see the following (Table 2).

Table 2. Expenditures on research and development as a percentage of the GDP of the countries of the European Union and the leading countries of the world in the period 2014-2021. Notes: * In Estonia, in 2011, the indicator of Research and development expenditures (% of GDP) was the highest for the period since 1998 and amounted to 2.305%; ** In Finland, in 2009, the indicator of Research and development expenditures (% of GDP) was the highest for the period since 1998 and amounted to 3.734%; *** In Ukraine in 1997, the indicator of Research and development expenditures (% of GDP) was the largest for the period from 1997 and amounted to 1.192%. *(Source: The World Bank. https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS)*

Countries		Research and development expenditures (% of GDP)	
	Values for 2014	Maximum or *minimum* value after 2014/year	The value of the last known 2020 year
1	5	6	7
Austria	3.084	*3.05 / 2015*	3.201
Belgium	2.38	3.4772 / 2020	3.4772
Bulgaria	0.79	0.949 / 2015	0.854
Great Britain	1.613	-	1.708 / 2019
Denmark	2.914	3.093 / 2016	2.962
Estonia*	1.43	*1.243 / 2016*	1.792
Israel	4.155	5.436 / 2020	5.436
Spain	1.242	*1.19 / 2016*	1.405
Italy	1.338	1.534 / 2020	1.534
Kazakhstan	0.167	0.17 / 2015	0.126
Canada	1.714	*1.592 / 2019*	1.698
China	2.022	2.401 / 2020	2.401
Republic of Korea	4.078	*3.978 / 2015*	4.814
Latvia	0.689	*0.435 / 2016*	0.706
Lithuania	1.03	*0.842 / 2016*	1.155
Netherlands	2.173	*2.139 / 2018*	2.294
Germany	2.878	3.168 / 2019	3.144
Norway	1.715	-	2.276
Poland	0.945	-	1.392
Romania	0.382	*0.503 / 2017*	0.47
Serbia	0.723	*0.919 / 2018*	0.906
Singapore	2.082	*2.174 / 2015*	1.891 / 2019
Slovak Republic	0.88	*1.161 / 2015*	0.911
Slovenia	2.365	*1.865 / 2017*	2.147
USA	2.722	-	3.45
Hungary	1.344	*1.18 / 2016*	1.608
Finland**	3.148	*2.724 / 2016*	2.935
France	2.276	*2.192 / 2019*	2.355
Croatia	0.774	1.248 / 2020	1.248
Czech Republic	1.958	*1.67 / 2016*	1.991
Sweden	3.102	-	3.527
Japan	3.368	*3.107 / 206*	3.263
Ukraine***	0.65	-	0.406
World	2.067	-	2.626
Central Europe and the Baltics	1.088	*1.022 / 2016*	1.314

It can be seen from the table that countries have different indicators of research and development expenditures, which is connected with differences in the development of the scientific sphere. On the other hand, the leading countries spend a much larger share of funds on scientific research compared to GDP than is spent in Ukraine.

Relative indicators are always insufficient evidence. With small volumes of the base, in this case, GDP, the absolute amount of costs can be sufficient only with a large relative indicator. On the contrary, a large base - a significant amount of GDP - allows attracting a smaller percentage of funds and at the same time having enough financial resources for the implementation of planned programs (projects, events). To confirm this, let's give an example comparing two countries: Israel is the leader in 2020 in terms of the specific weight of research and development expenditures, and the United States is the undisputed leader in terms of the absolute indicator of such expenditures. Israel had the largest share of research and development spending in 2020 of any country in the world. It accounted for 5.436% of GDP in the amount of USD 402.64 billion [29]. The USA had a smaller share of 3.45% with a GDP of USD 20,893.74 billion [30]. Based on the given absolute indicators of the GDP of these countries, the amount of research and development expenditures in Israel amounted to USD 21.89 billion, and in the United States $720.83 billion. As for Ukraine, with a GDP of USD 156.62 billion [31] and 0.406% of research and development costs, the absolute value of these costs was USD 0.636 billion.

The scale of national economies undoubtedly affects the absolute rate of research and development expenditures. On the other hand, the adequacy of the specified costs when taking into account the potential capabilities of each state can also be assessed by the specific indicator of these costs per unit of GDP value. If we divide the amount of research and development expenditures by the size of GDP, then we will get the specific weight of research and development expenditures in the gross domestic product or the sum of these expenditures per one USD of GDP. Such a specific weight was USD 0.054 in Israel in 2020 expenses/1 USD of GDP (21.89 : 402.64), in the USA 0.034 dollars expenses/1 dollar of GDP (720.83 : 20893.74), in Ukraine 0.004 dollars expenses/1 dollar of GDP (0.636 : 156.62). A comparison of specific indicators between Israel, the USA and Ukraine allows us to see the following. First, the smaller scale of the Israeli economy compared to the US economy requires spending a larger percentage of funds from GDP to ensure innovative economic development. Secondly, in Ukraine, an extremely small share of funds relative to GDP is spent on research and development, which, as is well known, determines the backwardness of the national economy in innovative development from the leading countries of the world.

A comparison of specific indicators together with absolute indicators proves the advantages of large countries with a large-scale economy. Thus, large economies may have a lower share of research and development spending, but they have significant financial resources for innovative programs and projects. As for Ukraine, as of 2020 and 2021, the country's economy was not strong enough to implement significant innovation programs. Instead, research and development costs were too small, insufficient for the innovative progress of individual industries and the state as a whole. The reasons for this situation are explained by the ancient and recent past.

The practice of funding fundamental and applied research developed in Ukraine a long time ago. It can be assumed that this practice of financing has been preserved since the times when the state form of ownership prevailed and, accordingly, financing was carried out by the state through the state budget. This meant the absence of a market approach to the needs of scientific and technological developments. The change in the forms of ownership of enterprises came into conflict with the prevailing rules of science funding. The state finances science in isolation from the real needs of product manufacturers, and from the needs of consumers of certain types of goods. Due to such a contradiction, the state financial authorities do not understand the prospects of various research, development and production. The consequence of this is the reduction of funding allocated to scientific institutions. After all, this method of funding takes place without a real vision of market demands, both from the side of consumers of goods and services and from the side of product manufacturers and service providers. This can be seen from the dynamics of state budget expenditures of Ukraine (Table 3).

Table 3. Expenditures of the state budget of Ukraine under the article National academies (program classification) in 2018-2021.
(Source: Data of the Ministry of Finance of Ukraine were obtained from the source of the Ministry of Finance: as of January 25, 2022, https://index.minfin.com.ua/ua/finance/budget/gov/expense/)

Years	Amounts of expenditure	
	million UAH	% to the total amount of budget expenditures
2014	5783,3	1.34
2015	5472,9	0.95
2016	5429,8	0.79
2017	7367,0	0.88
2018	9019,0	0.91
2019	10288,0	0.96
2020	10347,6	0.80
2021	14461,7	0.97

DOI: 10.55643/fcaptp.6.47.2022.3917

In Ukrainian practice, fundamental and some applied scientific research are financed through the National Academies. Of course, part of scientific research (fundamental and applied) is conducted in universities. Instead, it is impossible to allocate financial resources for the mentioned works from the budget of the Ministry of Education and Science based on the information of the Ministry of Finance of Ukraine. After all, our goal in this context is not so much to determine the absolute values of basic and applied research funding, but rather to analyze the trends (increasing or decreasing) in the funding of National Academies that direct funds to research and development. At the same time, we assume that the share of funds for research and development increases or decreases in accordance with changes in the total amount of expenditures determined by the budget.

The analysis of the data of the Ministry of Finance of Ukraine indicates a certain stability in the allocation of funds for the National Academies. It is obvious that the absolute amount of expenditures in hryvnia equivalent is growing. Instead, the specific gravity remains almost unchanged. The financing of the National Academies took place in such a way that the maximum share of their expenses in the state budget was 1.34% in 2014, and the minimum was 0.79% in 2016. Instead, a certain downward trend can be observed in the financing of institutions primarily responsible for fundamental research. The innovativeness of the national economy depends on the level of fundamental research and its results. Although it is clear that not all academies and their institutes conduct research on constructive materials, the latest substances, and technologies. Other important areas of social life depend on those academies that deal with humanitarian issues, but not innovations in production processes. This means that research and development costs are even lower (by the amount of funding for academies and institutes that do not have a technological direction). Thus, the results of the conducted analysis indicate a certain stability in the growth of financing amounts, but such stability is unlikely to be positive. After all, the percentage of budget expenditures under the article "National Academies" shows a downward trend, which, taking into account the constant inflationary effects, means a negative phenomenon.

It is generally accepted that the best financing in market conditions is provided by private owners. In this way, certain funds, joint-stock companies, etc., are created. In other words, the lack of state funding in the innovation sphere is largely compensated by private initiatives. Appropriate organizational forms are necessary for the effective use of state or municipal funds, as well as funds of private owners, and shareholders of joint-stock companies. The best financial support is a private initiative, an initiative of groups of innovators regarding research and development of new types of products through the formation and functioning of technoparks, and technopolises.

Publications of researchers of technopark problems testify to the following. As for scientific parks, the authors of the article [32] present their classification as follows. Incubators are the smallest structural formation. With the growth of assets and tasks solved by scientists, scientific (technological) parks, technopolises, and regions of science are created [32, p. 84]. Characterizing technology parks according to the American, European, Japanese, Chinese and mixed models, the authors note the following features. First, the location is either at universities (USA, Great Britain) or in separate buildings (Europe) or in isolated areas, sometimes outside industrial zones, as in China, necessarily in picturesque places in Japan [32, p. 86]. At the time of publication in 2020, the authors noted the presence of 16 technology parks in Ukraine among 600 technology parks in the world [32, p. 89]. Of course, the situation changed in 2022 as a result of the war. This will require a change in approaches to the creation of technology parks and the development of scientific research.

Perhaps it is worth creating scientific and technological clusters, which include several not only technoparks but also technopolises. This will make it possible to jointly use not only the scientific potential according to the matrix scheme but also the production capacities of the enterprises, which became smaller due to the destruction. The creation of scientific and technological clusters can take place both on the basis of universities and with the participation of already existing technoparks. Universities and existing technology parks can become the foundation of future science and technology clusters. The authors of the publication [33, p. 56] provide data on the number of technology parks in various European countries and note the scale of the process of their creation. Investigating the Ukrainian situation, it is noted that 40% of technology parks are fully financed by the state [33, p. 57]. It is quite clear that the state will not have such funds for technology parks in war and post-war times. The limited amount of funds, which should primarily be directed to the reconstruction of civil infrastructure, will not allow the use of budget funds. Therefore, on the one hand, one should try to mobilize the funds of private legal entities and individuals, on the other hand, they should be used sparingly. Scientific and technological clusters can become an effective organizational entity to meet both of the specified conditions.

Separately, we should emphasize the idea of creating a network of ecological technoparks in the territory of the Volyn region [34]. The authors of this research note a number of settlements in the Volyn region where technoparks can be created. This direction of development is approaching our vision of scientific and technological clusters. In addition, the formation of technoparks with an ecological direction of activity corresponds to the European vision of the prospects for the development of industry on the continent.

Therefore, the relevance of creating technology parks in Ukraine is a recognized idea. However, taking into account the current situation and prospects for the development of the economy of Ukraine in the post-war period with the features of European integration, prove the need for the formation of a new approach to the use of the state's scientific, technological and financial potential. We propose to create scientific and technological clusters to solve this problem. Such a cluster should provide an opportunity to combine innovative approaches to the circular economy, taking into account the requirements of sustainable development.

An important aspect of the formation and development of a scientific and technological cluster is its components. The scientific and technological clusters should have the necessary components in their composition that will allow the implementation of the principles of the circular economy. Among such components should be scientific, design-technological, and production units. Such divisions, as Ukrainian practice shows, can be departments and laboratories of universities, as well as departments of institutes of the National Academy of Sciences of Ukraine. These divisions will act as scientific components of the cluster conducting fundamental and applied scientific research in the appropriate organization of the case. Design and technology institutes and bureaus are units that carry out work on the design and development of technological processes of manufacturing products. Manufacturing enterprises with appropriate experimental workshops and divisions produce trial samples of products, and subsequently, reproduce products in series in accordance with existing orders. There should also be testing grounds, sites, and sites in the case of testing devices. It is a common practice to create technoparks and technopolises, which unite the mentioned structural subdivisions that carry out scientific research, design, construction and testing works with samples of innovative technology. This practice can also become a certain foundation for the formation of scientific and technological clusters.

DISCUSSION

In the article, we present our own version of the circular economy research typology. We show research and development expenditures as a percentage of the GDP of the countries of the European Union and the leading countries of the world in the period 2014-2021, which are important for understanding innovative development. In contrast to the experience of leading countries, we point out insufficient funding, in particular from the state budget, of scientific and technical activities in Ukraine using the example of national academies. We emphasize the need to engage in the implementation of the circular economy on the innovative basis of such an organizational form of interaction between science and production as technoparks. We offer to create and develop scientific and technological clusters.

We agree with many conclusions in the researched publications. Their authors highlight the important trends of recent years and the results of the development of national economies based on the concept of the circular economy. On the other hand, there are still no generalizations regarding the typology of research and their results in the publications of recent years that have been analyzed. The insufficiency of recommendations regarding the implementation of the circular economy concept in Ukraine in the mentioned publications is also important. At the same time, the researched publications give reasons to believe that the prerequisites for defining a comprehensive approach to the implementation of circular economy principles at domestic enterprises have already matured.

Of course, our article has not yet covered the issue of organizational and legal procedures, economic measures and financial instruments for the implementation of programs and projects for the formation and functioning of scientific and technological clusters.

CONCLUSIONS

The article proposes and substantiates the methodological principles of the research. In particular, methods of analysis, comparison, induction, and statistical methods were used. This made it possible to thoroughly study a certain set of issues and draw appropriate conclusions.

Implementation of sustainable economic development involves the introduction of circular economy principles into production activities. From such positions, a study of current publications was carried out, which reflect the latest achievements of science and practice of the leading countries of America, Europe, and Asia. Based on the results of research by domestic and foreign scientists, a typology of circular economy research was compiled. This made it possible to determine the author's direction of studying the problems of sustainable development and circular economy, which is formulated as an integration of the views of previous researchers. For this direction of research, we have proposed such a sign of typology as the search for directions for the formation and development of a scientific and technological cluster. As a means of

DOI: 10.55643/fcaptp.6.47.2022.3917

implementing circular economy programs, projects, measures, the definition and formation of funding sources for scientific and technological clusters are proposed.

The consideration of the problem of financing research and development in Ukraine in comparison with the countries of Europe, North America and Asia showed an extremely weak side of the activity of the Ukrainian state. Taking into account the practice of previous years in this area, as well as the state of war in Ukraine since February 2022, a conclusion was made that it is impossible to correct the situation in the coming years with the help of budget funding. Based on the results of the analysis of the specific weight of research and development costs in relation to GDP, a low level of funding for this area of activity in Ukraine was revealed. It is necessary to involve business circles in the financing of research and development. Instead, technoparks can be organizational forms of carrying out such works. Taking into account the world experience of creating technoparks with the participation of universities or territorially separated structures, as well as existing domestic technoparks, it is proposed to form scientific and technological clusters. The creation of scientific and technological clusters as a combination of technology parks, universities, and manufacturing enterprises will allow the most efficient use of both scientific potential and production capacity under current conditions. This should be facilitated by a matrix system of management of all types of resources.

A study of the place and role of technoparks was conducted. Foreign experience shows that their number is growing. The proposals of domestic specialists regarding the creation of technoparks testify to the perspective of such an organization of cooperation of scientific, educational, design-technological and production teams. Some proposals are very close to our proposed idea of creating scientific and technological clusters.

Prospective research in the area indicated by us should be the question of the peculiarities of integration of existing technoparks with universities, institutes of the National Academy of Sciences of Ukraine, and production enterprises.

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ЦИРКУЛЯРНА ЕКОНОМІКА Й ДЖЕРЕЛА ФІНАНСУВАННЯ НАУКОВО-ТЕХНОЛОГІЧНИХ КЛАСТЕРІВ

У статті з позицій сталого розвитку економіки розглянуто впровадження у виробничу діяльність принципів циркулярної економіки. Виконано дослідження актуальних публікацій, у яких відображені останні досягнення науки й практики провідних країн Америки, Європи, Азії та складено типологію досліджень циркулярної економіки. Запропоновано авторську ознаку типології – пошук напрямів формування й розвитку науково-технологічного кластера. Як засіб реалізації програм, проєктів, заходів циркулярної економіки запропоновано визначення й формування джерел фінансування науково-технологічних кластерів.

Проведено розгляд проблеми фінансування досліджень та розробок в Україні порівняно з країнами Європи, Північної Америки та Азії, який показав неможливість у найближчі роки виправити ситуацію з допомогою бюджетного фінансування. За результатами аналізу питомої ваги витрат на дослідження й розробки у співвідношенні до ВВП виявлено низький рівень фінансування цього напряму діяльності в Україні. Необхідність залучати до фінансування досліджень і розробок підприємницькі кола вимагає скористатись із такої організаційної форми проведення робіт, як технопарки. З урахуванням євроінтеграційних процесів і світового досвіду створення технопарків за участю університетів чи територіально відокремлених структур, а також наявних в Україні технопарків, запропоновано формувати науково-технологічні кластери. До складу науково-технологічних кластерів мають уходити технопарки, університети, інститути Національної академії наук України, конструкторсько-технологічні структури (інститути, бюро), виробничі підприємства. Це дозволить у нинішніх умовах найбільш ефективно використовувати науковий та інженерний потенціал і виробничі потужності за матричною системою управління всіма видами ресурсів кластера.

У статті запропоновано використання методів аналізу, аналогії, зіставлення, індукції, статистичний, що дозволило ґрунтовно вивчити визначений комплекс питань і зробити відповідні висновки.

Ключові слова: циркулярна економіка, науково-технологічний кластер, методологія досліджень, диверсифіковані підприємства, циркулярна економіка регіону, дослідження й розвиток фінансування, складові науково-технологічного кластера

JEL Класифікація: G38, H72, O33, O57