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State management and financial support of innovations: the example of Ukraine

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Abstract

The article discusses the current trends in innovation in Ukraine, their financial support and features of public management on the example of the defense and agricultural sectors, which are vital in the field of national security. The goal is to study the impact of new economic realities caused by systemic reforms and crisis processes on the innovative development of Ukraine in order to substantiate promising areas of innovative national security in terms of highlighting the conceptual foundations of financial support for innovation as a component of Ukraine's national security. To achieve the goals of the study, scientific tasks are defined: analysis of the regulatory regulation of state investment management, statistical analysis of financing costs and correlation analysis of macro indicators, the policy of forming an innovative economy in the countries of the world, industry specifics of individual sectors of national security. Methodological tools used in the research are methods of economic theory, the method of comparisons and statistical analysis for the disclosure of innovative analysis and its components; formalization method for work on direct strategic development. According to the analysis of the dynamics of funding of scientific and scientific and technical activity during 2010–2020, an increase in the specific weight of external funds, other sources and, accordingly, a decrease in the specific weight of budget financing, domestic and foreign customers, which calculated the results of the core of the innovative ratings of the country. The data of the econometric analysis of 2010–2021 show the dependence of the view on innovations and the increase of the main macroeconomic indicators. This will be confirmed by the ranking positions for the global innovation index. Foreign experience was analyzed and recommendations are made for its possible application in the national economy. Research will contribute to the further development, emphasis and coordination of governmental and international programs for innovative development being developed for it. The results of the study may be useful for the formation of a strategy for the innovative development of individual industries.

Keywords: financial support, innovative development, state management of innovations, strategy, national security, defense industry, agro-industrial complex, Ukraine.

1. Introduction

The problems of national security of countries in the light of modern global events arise quite sharply. This is due to the fall in commodity, stock and financial markets, increased economic and political confrontation, armed and hybrid conflicts, man-

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made disasters, climate change, quarantine restrictions and a decline in economic growth due to the COVID-19 pandemic and other factors. The solution of these problems encourages the countries of the world to strengthen management, regulation, cooperation and interaction in this direction.

For Ukraine, based on the new Law on National Security No. 2469–VIII (June 21, 2018), the solution of problems is reduced mainly to protection from military dangers. World experience convinces that the aspect of security is also related to the economy, finance and innovation, balanced sustainable development and food security. Thus, according to the statistics of the European Commission on Science, Technology and Innovation (2022), developed countries provide up to 85–90 % of GDP growth due to «intensive factors», including innovation, and the market for high-tech products is growing every year.

The National Strategy for the Development of the Sphere of Innovative Activities for the Period until 2030 (2019), emphasizes that the development of innovative potential is not only a path to dynamic development and success, but also a means of ensuring the security and sovereignty of the state, its competitiveness in the modern world. This Strategy is cross-sectoral, aimed at solving the issues of development of innovation activities common to all sectors of the economy, and developing links between them.

Therefore, it is necessary to study the state and ways of increasing the innovative potential and competitiveness of the Ukrainian economy through the prism of public management and financial support for innovations as components of the national security of Ukraine.

2. Literature Review

The world scientific community has been studying this issue since the late 30s of the last century and has significant achievements and implementation in practice.

According to Mazzucato (2017), governments are increasingly aiming for smart economic growth due to innovative, inclusive and sustainable development. The modern approach is characterized by a departure from a narrow sectoral industrial policy and focuses on the problems of system-wide transformation in various areas through the partnership of the state, business and society. (Jugend et al. 2018) proved the relationship between open innovation, innovation efficiency and government support for innovation, and in general, innovation requires program synergy. (Mayer 2010) explores the impact of the open innovation model on public policy, in particular on economic development practices in countries with low levels of scientific research, which can benefit from the creation of Marshallian externalities.

The impact of the EU's 7th Framework Large Scale Research Grant Program on innovation has been assessed by Szücs & Florian (2018), focusing on industry-university partnerships. Conclusions have been drawn about the positive assessment of spillovers of knowledge in terms of government R&D policy, economic incentives and the behavior of private firms (Feldman, 2006). The differential impact of state support on R&D of firms is considered (Lee, 2011). Kang & Park (2012) uncovered the impact of government support for R&D and collaboration on innovation. The structure of innovation financing as a factor in economic growth through the analysis of indicators between countries was studied by Rzayev & Samoilikova (2020), etc.

A layer of research is devoted to innovations in individual sectors. Mowery (2012) explored that national defense accounts for a large proportion of the R&D budgets of most OECD countries and an even higher share of their defense mission spending. Domestic fundamental research on innovative development is implemented in the works of Geitz et al. (2015). Researchers Azhaman & Slivka (2019) revealed trends in the state of financing of innovative activities, Kolodizev (2009) showed the methodological foundations of financial support for managing the innovative development of the economy, Vovchenko (2019) assessed the modernization of the national security strategy of Ukraine in the context of innovative development with an emphasis on economic security 2020) – the level of potential of state regulation of innovation activity, Omelianenko & Linnik (2020) analyzed the digital component of the innovation basis of national security, Tarasyuk & Malyarchuk (2017) studied the current state of the implementation of innovation policy in Ukraine and its financial support, Turko (2018) revealed trends in the development of production in Ukraine, Frolova and Frolov (2020) explored the institutional features of international innovation finance in Ukraine.

The issues of innovation management in the military-industrial complex (DIC) were studied by Omelianenko (2018) in terms of the strategic aspects of the formation of innovation networks, Zgurets (2016) studied the problems of the army of the future through a dual look at innovation. Usachenko (2018) disclosed the organizational and managerial mechanisms for regulating the state defense order, Ferdman (2019) studied innovative activities in the system of transport and national security, Begma & Svergunov (2019) revealed the conceptual foundations of strategies for investment and innovative development of the military-industrial complexes of the states of Ukraine, etc.

Considering the lag of Ukraine in many indicators of innovative development, which has become an organic component of national security, there is a need to analyze the state of management and financing of innovations, taking into account the scientific heritage and world practice in this area, which requires constant adjustment of the formation of a strategy and the implementation of the country's innovation policy in the field of national security. security.

3. Methodology

The methodological tools of the study were the methods of economic theory in terms of state regulation of innovations; budget financing of this process, a method of comparison and statistical analysis to identify the features of innovative development and its components; a method of formalizing the choice and hierarchy for choosing the directions of the innovation development strategy.

The study period was 2010–2021.

The object of the study was the financing of science, since it is directly related to the introduction of innovations and the financing of investment activities of industrial enterprises, since statistics are available for this category.

The statistical information sources of the study were the data of the State Statistics Service of Ukraine on the financing of the scientific sphere of Ukraine at the expense of the state budget according to the data of the main administrators.

Dependency and financing model.

Shepotilo (2020) has developed a general equilibrium model for the global economy that demonstrates the relationship of economic growth with labor market developments, investment, research and development, and trade. For investments, the link of the model depends on the parameter of the total factor productivity A_it and evolves in accordance with the law of motion:

$$Ai,t+1 = (1 - \delta Ai)Ait + \gamma Tit + Ai + At + ei \quad (1)$$

The current level of knowledge and the state of technology, taken into account in determining the total productivity of production factors, A_it depreciates over time at the rate δ_Ai. T, representing the contribution of knowledge and technology, depends on the level of investment in innovation and production technologies, the inflow of technological capital, and investment in human capital and education:

$$Tit = FT(R\&Dit, FDIit, EDUit) \quad (2)$$

The level of technology also depends on the effectiveness of institutions and governments helping to reduce transaction costs, which adds a fixed component of A_i, in addition, the overall level of technology is constantly growing due to technology investments and the accumulated knowledge of other countries, which becomes common knowledge over time, which adds the A_t component.

A simplified approach to this equilibrium model suggests that there is a close relationship between innovation factors and macro indicators (capital market, labor market, investment market). To build econometric models based on the method of (Chupilko et al. 2017) we chose the following factors to build the model (Table 1).

Table 1

Statistical data for building econometric models

	GDP, million dollars	Exports, million dollars	Imports, million dollars	Investments million dollars	Inflation, %	Unemp-loyment, %	Science in GDP, %	Science in budget, %
	(Y)	(X1)	(X2)	(X3)	(X4)	(X5)	(X6)	(X7)
2010	136419	51430	-60739	45,370	109,1	8,8	0,75	3,27
2011	163160	68394	-82608	48,198	104,6	8,6	0,65	3,03
2012	175781	68809	-84658	51,705	99,8	8,1	0,67	2,06
2013	183310	63312	-76963	53,704	100,5	7,6	0,70	1,89
2014	131805	53901	-54428	40,725	124,9	9,7	0,60	2,44
2015	90615	38127	-37516	36,154	143,3	9,5	0,55	2,24
2016	93270	36361	39249	37,655	112,4	9,7	0,48	3,21
2017	112154	43300	-49000	16,016	109,5	9,9	0,45	3,00
2018	130832	47300	-57100	20,668	108,7	9,1	0,47	2,38
2019	153781	51000	-67700	22,268	103,9	8,6	0,43	0,93
2020	155582	49192	-54336	17,980	105,0	9,9	0,41	0,78
2021	200090	63113	-69755-	19,920	110,0	10,3	0,40	0,75

Sources: indicate by the authors based on Minisrty of finance of Unkraine, https://index.minfin.com.ua/ua/economy/index/inflation/

The model of dependence of GDP on exports, imports, investment, inflation, unemployment, research spending in GDP (and in budget expenditures on the economy) using the Eviews econometric analysis package in a multivariate linear regression model will look like this:

$$Y = f(X1, X2, X3, X4, X5, X6, X7) \quad (3)$$

$$Y = b0 + b1x1 + b2x2 + \ldots + bpxp + E \quad (4)$$

Where: Y is an independent variable; $x1, x2, \ldots, xp$ are independent factors; $b0, b1, b2, \ldots, bp$ are model parameters; E – error.

4. Results and discussions

4.1. Result: Regulation of state investment management

In the Law on the National Security of Ukraine No. 2469–VIII (June 21, 2018), according to Art. 3 p. 4.4 it is noted that the state policy in the areas of national security and defense is aimed at ensuring military, foreign policy, state, economic, informational, environmental security, cybersecurity of Ukraine, etc. The National Security and Defense Council of Ukraine approved, and the Decree of the President of Ukraine dated September 14, 2020 No. 392/2020 approved the National Security Strategy of Ukraine. The Strategy provides for: financial conditions for the development of science, ensuring the development of research infrastructure, as well as the effective interaction of scientists with the public and private sectors, stimulating innovation and introducing the latest technologies, in particular in the areas of security and defense, healthcare, industry, energy, engineering, agriculture, construction and infrastructure, sports, information and telecommunications.

In turn, the Law of Ukraine On priority areas of innovation activity in Ukraine (2011) defines such areas of innovation activity that are aimed at ensuring the economic security of the state, creating high-tech competitive environmentally friendly products, providing high-quality services and increasing the export potential of the state with the effective use of domestic and world scientific and technological achievements

For 2019, the state for the first time provided funds for basic funding of science at universities, according to which science at universities for the first time will begin to really compare in institutional capacity with science at research institutions, and as part of the attestation, individual scientific areas will be evaluated: and veterinary sciences Military sciences and homeland security, Humanities and arts, Social sciences, Biology and health sciences, Mathematical sciences and natural sciences, Engineering sciences. Based on the assessment of each scientific direction, the university will be assigned to one of three groups – A, B, C. Until that time, the total funding for the sections.

The current state of the national innovation system of Ukraine is characterized by the presence of scientific (institutions of the National Academy of Sciences of Ukraine, branch research centers and institutes, higher educational institutions) and industrial and commercial components (manufacturing enterprises, regardless of the form of ownership). Budget financing of scientific and scientific and technical activities is carried out in accordance with the legislation of Ukraine. The normative field of financial security is embodied in Art. 48 Financial support of scientific and scientific and technical activities of the Law of Ukraine On Scientific and Technical Activities (2012) (Table 2), carried out at the expense of state and local budgets, funds of institutions, organizations and enterprises, domestic and foreign customers of works, grants, other sources not prohibited by law.

Objects of budget financing in innovation: 1) priority areas of scientific and technological progress; 2) targeted budget programs; 3) sectors of science conducting basic and exploratory research.

In the priority areas of scientific and technological progress, the state budget finances comprehensive innovative programs, state scientific, technical and international programs (Wozniak and Kuznetsova, 2007).

Resolution of the Cabinet of Ministers No. 571 (July 22, 2015) approved the procedure for selecting state investment projects. When preparing a state investment project, its economic evaluation is carried out by analyzing it depending on the purpose (making a profit and / or achieving a social effect) and the scale of the investment project, in particular, its cost: up to 30 million hryvnia inclusive – cost-effectiveness analysis; over UAH 30 million – cost-benefit analysis.

This assessment is carried out by the developer of the state investment project, taking into account international recommendations and recommendations developed and approved by the Ministry of Economy and posted on the official website. The calculation of economic efficiency indicators for the implementation of a state investment project is carried out taking into account the methodological recommendations for the development of an investment project, for the implementation of which state support may be provided, or the preparation and evaluation of a state investment project, approved by the Ministry of Economy.

4.2. Result: Spending money

In economic science and practice, a fairly clear classification of financial resources used to finance innovation has developed. According to the form of financing, it is divided into: a) direct financing (off-budget funds; own funds of enterprises (organizations); special funds, innovative foreign loans, etc.); tax incentives; tax credits; credit benefits, etc.).

According to the level of management, the sources of financing innovations are divided into:

a) state (state budget, off-budget funds, special funds, borrowed funds, loans, etc.);

b) sectoral (sectoral and intersectoral non-budgetary funds, borrowed funds, budgetary and bank loans, etc.);

c) regional (regional, regional, local budget, private state budget, loans, innovative investments, etc.);

d) institutional (enterprises, organizations, own funds, budgetary funds, non-budgetary funds, loans, funds of FIGs, etc.). The total costs of research and development by type of work for 2010–2020 are given in Table 2.

Table 2

Expenditure on research and development by type of work for 2010–2020 (million dollars)

	Research costs, total	including pursuant to						Share of expenditu-res in GDP, %
		fundamental		applied		scientific and technical		
		amount	in % of expenses	amount	in % of expenses	amount	in % of expenses	
2010	1021,045	273,9295	26,8	200,1763	19,6	546,9395	53,6	0,75
2011	1068,181	276,1355	25,9	227,591	21,3	564,4542	52,8	0,65
2012	1178,961	327,3217	27,8	253,2165	21,5	598,423	50,7	0,67
2013	1282,666	337,6971	26,3	257,9975	20,1	686,9712	53,6	0,70
2014	797,9394	206,2237	25,9	158,3431	19,8	433,3726	54,3	0,60
2015	503,8278	112,6465	22,4	89,77106	17,8	301,4103	59,8	0,55
2016	451,2994	87,11155	19,3	100,2427	22,2	263,9452	58,5	0,48
2017	502,9812	109,9436	21,9	118,9173	23,6	274,1203	54,5	0,45
2018	616,6801	138,1066	22,4	131,1875	21,3	347,386	56,3	0,47
2019	667,4894	144,6963	21,7	140,646	21,1	382,147	57,2	0,43
2020	631,3947	157,9748	25,0	147,3071	23,3	326,1165	51,6	0,41

Sources: indicate built by the authors according to the State Statistics Committee of Ukraine, 2022 URL : http://www.ukrstat.gov.ua/

According to the given data, there is a tendency to reduce the share of costs for research and development by type of work from 0,75 % in 2010 to 0,41 % in 2020, and the indicator of the last year is the lowest. the distribution of costs for the implementation of fundamental, applied, scientific and technical developments remains almost stable over the years, and the volume of total funding in 2020 is 210 % of the 2010 level in hryvnias and 62 % in dollars.

Empirical and theoretical trend line of the costs of research and development in Ukraine for the period 2010–2020 in hryvnia (left side) and dollars (right side) is shown in fig. 1.

An econometric analysis of cost dynamics based on the construction of polynomial trend models is used to describe the uneven dynamics of time series observed in 2014 and 2016. Statistical evaluation of the obtained econometric modeling confirmed the conclusion about the existence of a cost growth trend over the period.

The coefficient of the polynomial equation ỹ = 0.1237x2-0,3584x + 8,7816 shows an annual increase in spending on financing science by UAH 0,124 billion, and if this trend continues, the costs of scientific research and development in Ukraine will reach UAH 25,0 billion by 2022 against UAH 17,25 billion in 2019.

Structure of research and development funding by sources in 2010-2019 is given in table 3.

There is a tendency to reduce budget funds from 41 to 39 %, a significant increase in the use of funds from Ukrainian customers.

In the context of the areas of budget financing and priority areas in 2019, the largest volumes of expenditures from the general fund were directed to the implementation of: applied R&D – in such priority areas as:

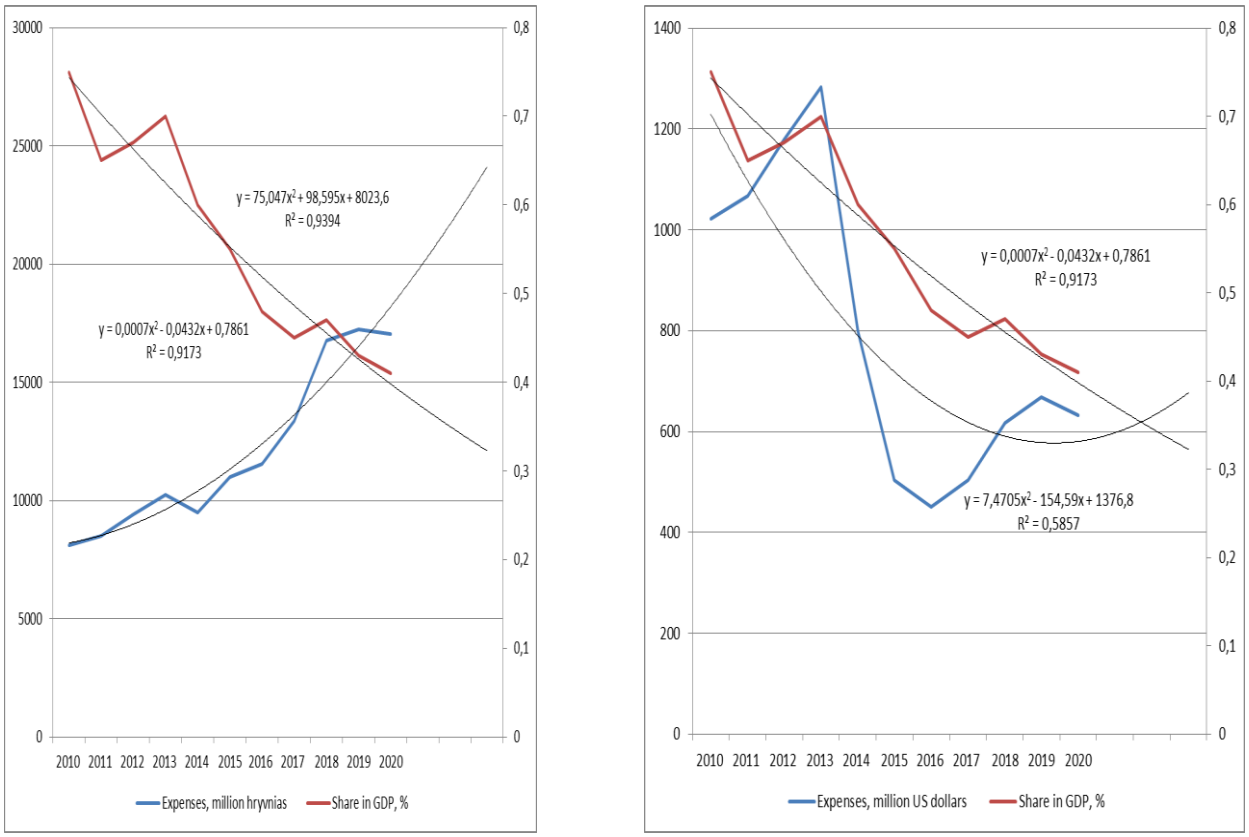
– «Life sciences, new technologies for the prevention and treatment of the most common diseases» (42,7 %) and «Rational nature management» (18,7 %);

– GTsNTP – in the priority areas «Life sciences, new technologies for the prevention and treatment of the most common diseases» (58,0 %) and «Basic scientific research» (37,5 %);

– developments under the state order – in the priority areas «Life sciences, new technologies for the prevention and treatment of the most common diseases» (21,8 %) and «New substances and materials» (21,1 %);

– projects within the framework of international scientific and technical cooperation – in the priority areas «Energy and energy efficiency» (25,0 %) and «Life sciences, new technologies for the prevention and treatment of the most common diseases» (20,6 %).

In terms of areas of budget financing and priority areas in 2020, the largest expenditures; much less – for scientific and technical (experimental) developments under the state order – 0,5 %, for state targeted scientific and scientific and technical programs – 0,4 % and for projects within the framework of international scientific and technical cooperation – 0,3 %.



Sources: built by the authors according to the State Statistics Committee of Ukraine

Fig. 1. Empirical and theoretical trend line of costs for research and development in Ukraine according to 2010–2020 data, UAH bln

Table 3
Funding for research and development in Ukraine by sources in 2010–2020, %

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget Funds	41,4	40,5	44,9	42,9	39,3	34,8	32,1	36,6	37,1	39,0	43,5
Funds of Customers of Ukraine	1,7	13,1	21,6	20,7	20,8	20,1	32,4	27,9	30,5	28,1	27,2
Funds of Foreign Sources	25,7	25,0	19,4	21,6	19,8	18,2	22,1	24,4	21,7	22,3	23,9
Own Funds	9,7	8,0	10,6	13,1	18,7	24,6	10,0	10,0	9,6	10,0	12,3
Funds of other sources	1,4	1,1	1,8	1,7	1,4	2,3	3,4	1,1	1,1	0,5	0,40

Sources: indicate by the authors on State Statistics Committee of Ukraine, 2022

In terms of areas of budget financing and priority areas in 2020, the largest volumes of expenditures of the general fund were directed to the implementation of: applied R&D – in such priority areas as:

«Life sciences, new technologies for the prevention and treatment of the most common diseases» (40,2 %) and «Rational nature management» (21,3 %);

– GTsNTP – in the priority areas «Fundamental scientific research» (43,4 %) and «Life sciences, new technologies for the prevention and treatment of the most common diseases» (40,2 %);

– developments under the state order – in the priority areas «Energy and Energy Efficiency» (26,9 %) and «Information and Communication Technologies» (20,5 %);

– projects within the framework of international scientific and technical cooperation – in the priority areas «Energy and energy efficiency» (24,6 %) and «Life sciences, new technologies for the prevention and treatment of the most common diseases» (20,5 %).

According to statistics, the National Academy of Sciences of Ukraine traditionally remains the largest among the main managers of budgetary funds for science.

In 2020, it was funded by UAH 3,44 billion, or 60 % of the total funding for science. The largest budget program at the same time in the National Academy of Sciences and in science as a whole traditionally remains the CPCCC of objects constituting a national treasure, ensuring the activities of scientific libraries with funding of 2880,2 million hryvnia or 44,0 % of the total science budget.

The Ministry of Education and Science of Ukraine (UAH 944 million or 17 % of the budget for science) is the next after the National Academy of Sciences with a large margin – 2,7 times less. The largest budget program of the Ministry of Education and Science and at the same time the second in terms of funding for science, studied by the review of expenditures by the CPCCC 2201040 objects that make up the national treasure, ensuring the activities of the State Fund for Fundamental Research.

After the highest concentration of budget funding in the National Academy of Sciences and the Ministry of Education and Science, the National Academy of Medical Sciences of Ukraine – 7,5 % and the National Academy of Agrarian Sciences of Ukraine – 7,4 % follow. The rest of the controllers are less powerful.

Table 4
Budget financing of fundamental and applied research and development in the sectors of the economy of Ukraine in 2016–2020, mln hryvnia

Basic and applied research and development	2016		2017		2018		2019		2020	
	planned	actually	planned	actually	planned	actually	planned	actually	planned	Actually*
In sectors of the economy	1073,0	1009,8	1494,6	1410,7	1635,2	1520,5	1462,8	1398,4	1767,2	896,3
sphere of economic, trade and labor activity	5,98	5,76	10,28	9,66	9,85	9,62	207,62	190,80	12,39	6,00
agriculture, forestry and hunting, fisheries	863,50	816,92	1388,5	1308,6	1445,9	1367,0	1166,2	1123,0	1651,6	879,3
fuel and energy complex	6,50	5,27	8, 96	6,06	8,96	6,78	-	-	-	-
other industries and construction	5,40	4,95	6,44	6,39	6,70	6,52	3,40	-	7, 43	1,62
other sectors of the economy	191,60	176,91	81,10	80,05	164,30	130,53	7,08	6, 54	95,00	9,00
Share in budget expenditures, %	0,121	0,121	0,134	0,133	0,123	0,122	0,100	0,102	0,108	0,087

* for the 3rd quarter of 2020

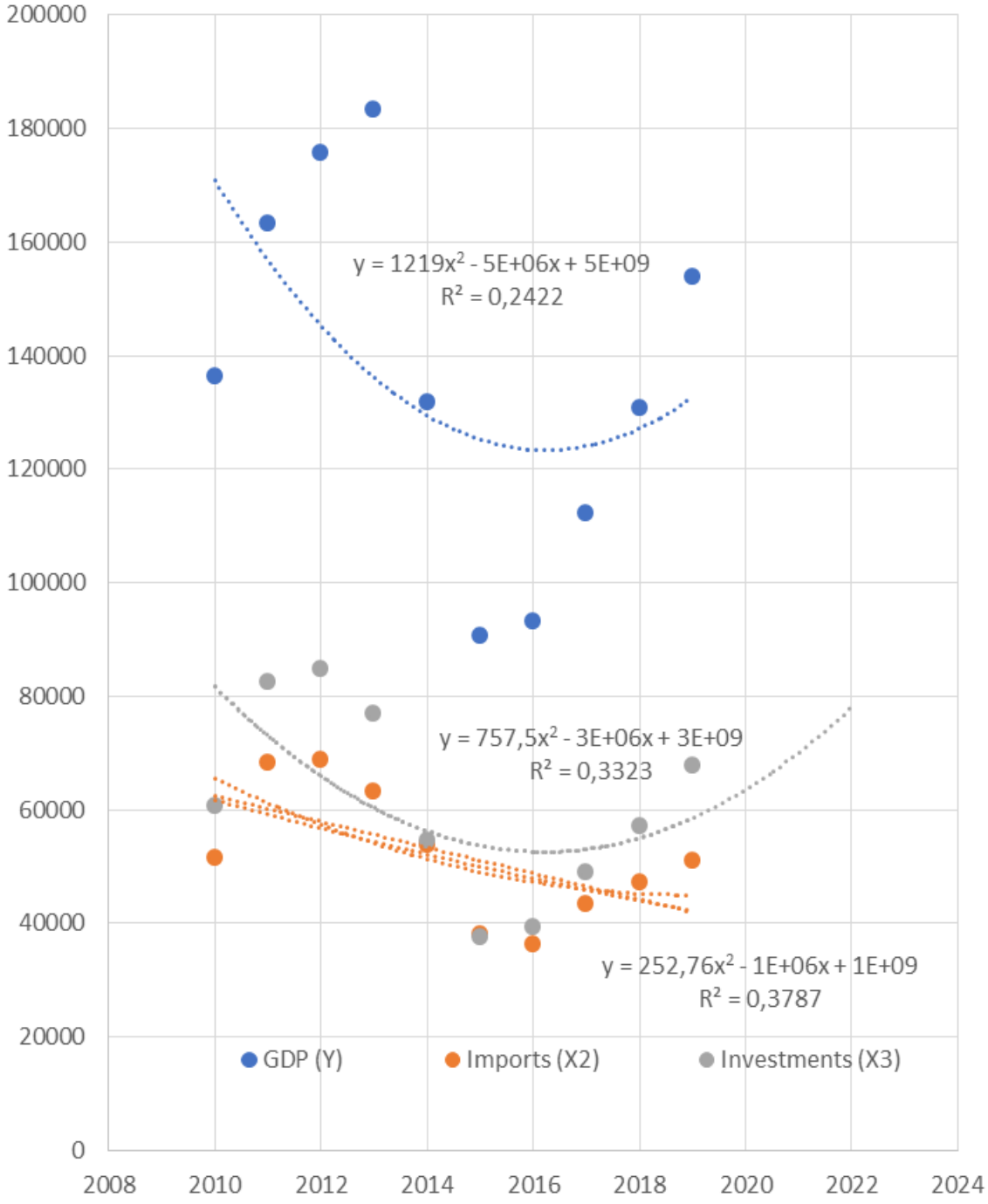
Source: calculated by the authors according to the State Treasury of Ukraine. URL : https://www.treasury.gov.ua/ru/file-storage/vikonannya-derzhavnogo-byudzhetu.

Zakharin (2020) analyzed that about UAH 813 million was allocated for the scientific and scientific and technical activities of scientific institutions and institutions of higher education in 2020. In the budget request for 2021, the Ministry of Education and Science of Ukraine proposed to increase the amount of expenses under this item to UAH 1,2 billion.

In addition, the draft law on state support for projects with significant investments has already passed the first reading. This means that investments over 20 million euros can receive 30 % compensation. areas: infrastructure, high technology, education – industries with high added value.

The Cabinet of Ministers of Ukraine has approved a list of priority investment projects for the state for the next 3 years. In total, the government has agreed on about a hundred projects, among which, as noted, the production of its own ventilators and the construction of a new airport.

On fig. 2–4 show the results of modeling the dynamics of the main macro-indicators in the projection for financing costs and developments in Ukraine for 2010–2021 in dollar terms. According to the data distribution trend analysis, GDP and other indicators have identical downward trends, except for inflation and unemployment.

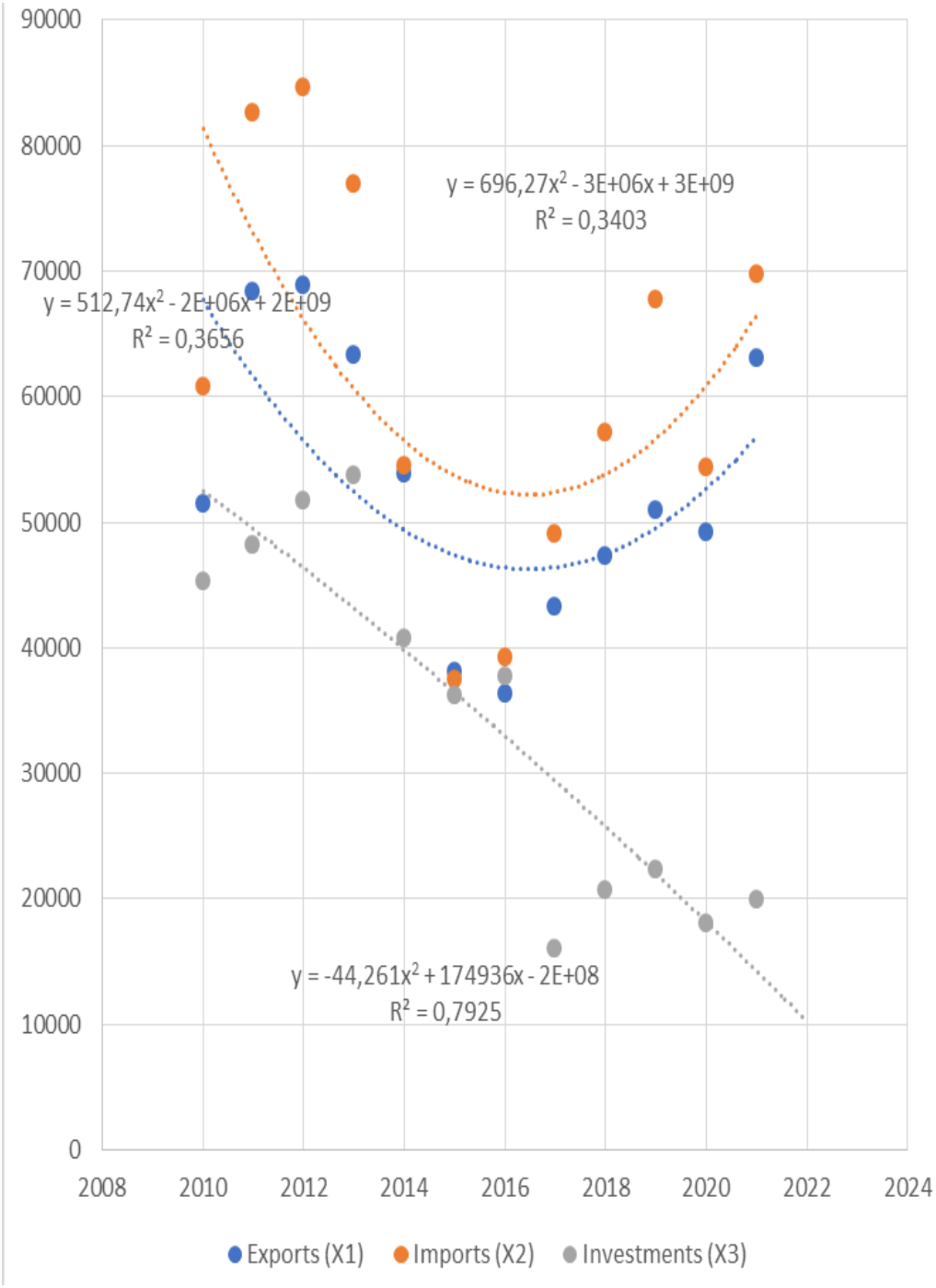


Sources: calculated by the authors

Fig. 2. Modeling the dynamics of GDP, exports and imports in 2010-2021 (in USD)

The science intensity of GDP is now considered as one of the most important features of the country's innovativeness (Berezniak, 2020).

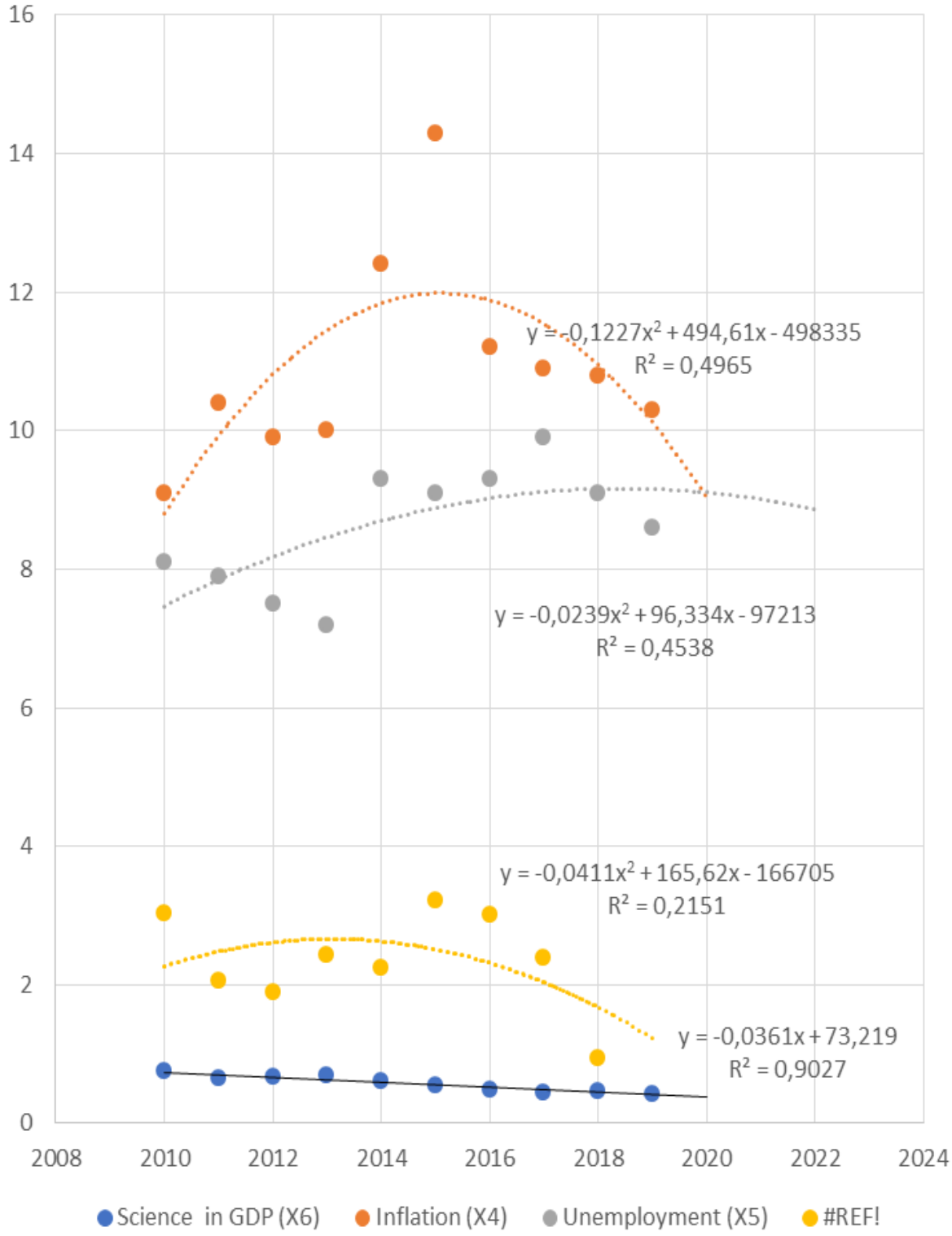
There are threshold values of the GDP science intensity indicator, which determine the ability of the scientific sphere to realize its main functions: socio-cultural, cognitive, economic (Brevnov and Erygina, 2016).



Sources: calculated by the authors on Vovchenko, 2019

Fig. 3. Modeling the dynamics of exports, imports and investments in 2010–2021 (in USD)

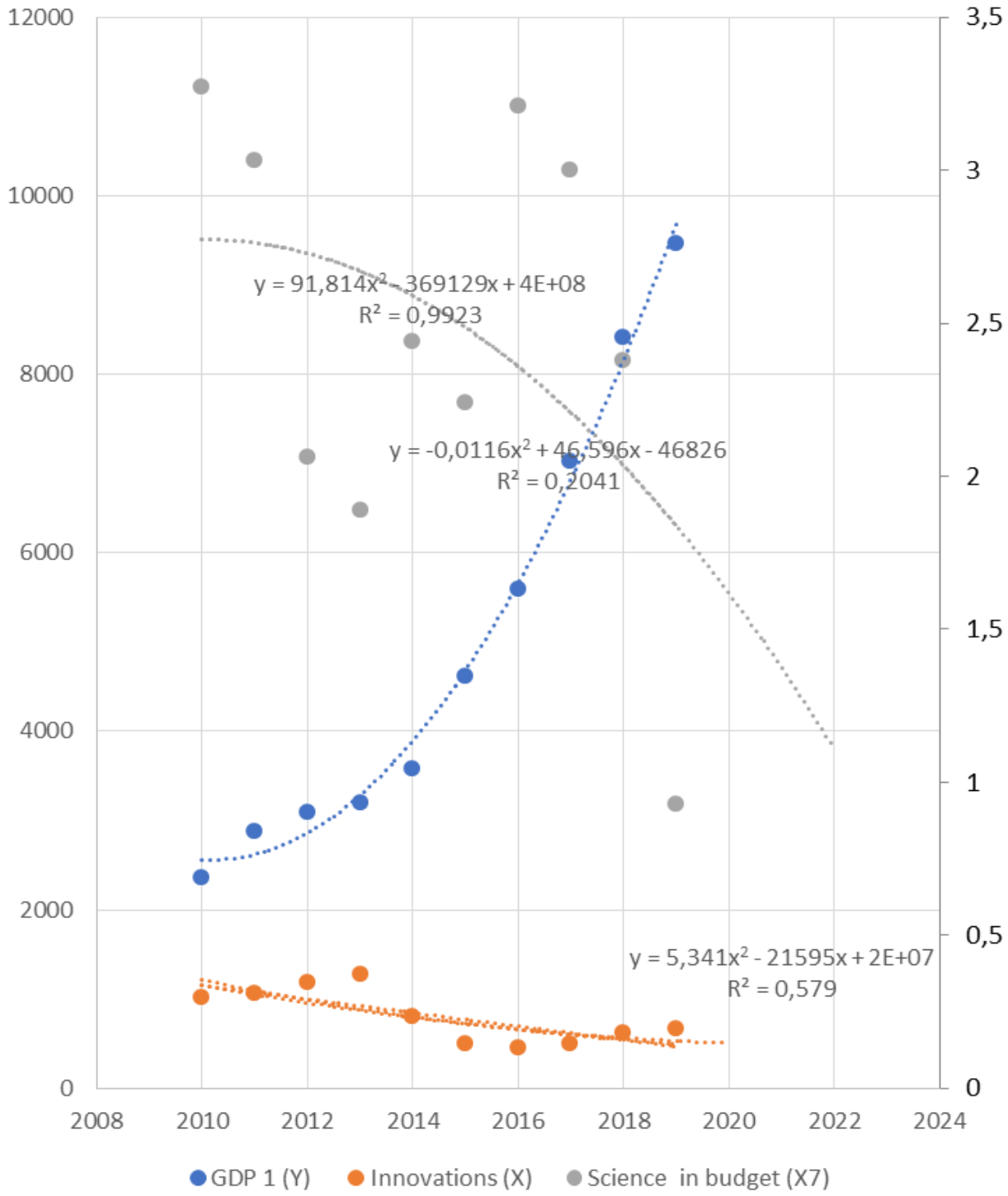
Another nature of the distribution of data shows the modeling of the relationship of these indicators in the national currency. In this case, all regressions have a very high coefficient of determination, so the measure of dispersion explained by the regression is from 92 to 96 % due to small deviations from the regression curves.



Sources: calculated by the authors

Fig. 4. Modeling the dynamics of the share of research expenditures in GDP, the share of research funding in budget expenditures on the economy, unemployment and inflation for 2010–2021

Exports, imports and foreign direct investment have the greatest impact on GDP change.



Sources: calculated by the authors

Fig. 5. Modeling the dynamics of GDP, innovation and the share of research funding in budget expenditures on the economy for 2010–2021

4.3. Result Falling ratings of Ukraine

When studying the financing of R&D in Ukraine, it should be noted that the volume of expenses for the implementation of scientific research compared to other countries is quite insignificant (Table 4) – in 2018 they amounted to about 0,49 billion dollars, which is calculated as a share of GDP is 0,45 %. NISI [2] empirically revealed a high and stable dependence of the technological level of the country's development on the science intensity of GDP. The indicator is calculated as the ratio of research costs to GDP. So, with a value of this indicator of 0,4–0,5 %, science performs a socio-cultural function; 0,6–0,9 % – maintains the existing technological potential; with a value above 0,9 %, it ensures the economic development of society. Almost all European countries have increased funding for research costs (Table 5).

Table 5
Share of intramural R&D expenditure in GDP (data by individual countries) (%)

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
EU 28	1,92	1,96	2,00	2,01	2,02	2,03	2,04	2,08	2,12	2,23	2,32
Bulgaria	0,57	0,53	0,60	0,64	0,79	0,95	0,77	0,74	0,76	0,83	0,85
Estonia	1,57	2,28	2,11	1,71	1,42	1,46	1,25	1,28	1,40	0,63	1,79
Spain	1,36	1,33	1,30	1,28	1,24	1,22	1,19	1,21	1,24	1,25	1,39
Latvia	0,61	0,70	0,66	0,61	0,69	0,62	0,44	0,51	0,64	0,69	0,71
Lithuania	0,79	0,91	0,90	0,95	1,03	1,04	0,84	0,90	0,94	0,99	1,16
Germany	2,73	2,81	2,88	2,84	2,88	2,93	2,94	3,07	3,13	3,17	3,14
Poland	0,72	0,75	0,88	0,87	0,94	1,00	0,96	1,03	1,21	1,32	1,39
Romania	0,46	0,50	0,48	0,39	0,38	0,49	0,48	0,50	0,50	0,48	0,47
Slovakia	0,61	0,66	0,80	0,82	0,88	1,16	0,79	0,89	0,84	0,83	0,91
Slovenia	2,05	2,41	2,56	2,56	2,37	2,20	2,01	1,87	1,95	2,05	2,18
Hungary	1,14	1,19	1,26	1,39	1,35	1,35	1,19	1,33	1,53	1,48	1,01
Czech	1,34	1,56	1,78	1,90	1,97	1,93	1,68	1,79	1,93	1,93	1,99
Ukraine	**0,75**	**0,65**	**0,67**	**0,70**	**0,60**	**0,55**	**0,48**	**0,45**	**0,47**	**0,43**	**0,41**

Sources: indicate on Data source for EU countries, 2022. URL: https://ec.europa.eu/eurostat/web/science-technology-innovation/data/database/

In the developed countries of the world, significant attention is paid to the financing of R&D. For example, the leading countries with the highest level of spending on R&D include: Israel (4,74 %), Sweden (3,63 %), Finland (3,47 %), Japan (3,39 %), South Korea (3,22 %), USA (2,68 %).

A noticeable increase in spending on science in the EU began in 2008–2009 and continues to this day. In the European Union as a whole, the indicator of knowledge intensity of GDP increased from 1,77 % in 2000 to the historically largest 2,06 % of GDP in 2017.

The main sources of funding for science are the business and public sectors. In the EU-28, they together provided 87,5 % of research funding in 2016.

From 2010 to 2015–2017 public funding for science has been declining in favor of the business sector in almost all countries. A notable exception was Latvia, where the share of public sector funding for science in 2015–2017 was to 41,8 % and 31,9 % in 2016–2017).

According to the World Economic Forum The Global Competitivenes Report (2022), according to the criterion of investing financial resources in R&D, which underlie the development and full implementation of innovative activities, in 2016 Ukraine ranked 56 out of 128 countries, in 2017 – 50 out of 127 countries, in 2018 – 43rd place out of 126 countries, in 2019 – 47th place out of 129 countries, in 2020 – 45th place out of 131 countries and in 2021 – 49th place out of 132 countries, which indicates a deterioration in Ukraine's position in 2021 year.

So, in 2021, the seven components of the GII for Ukraine were: results of knowledge and technology – 33rd place; human capital and research – 44th place; results of creative activity – 48th place; business development – 53rd place; market development – 88th place; institutions – 91 places; infrastructure – 94th place. It was revealed that the strengths of Ukraine are the results of knowledge and technology; human capital and research; and the weaknesses of institutions and infrastructure.

According to the data published on August 5, 2020 in the OECD (2022), the database of basic indicators of science and technology (MSTI), intensity of research and development (R&D) (R&D spending as a percentage of gross domestic product, GDP) in the OECD area increased from 2,34 % in 2017 to 2,38 % in 2018. This increase, following a similar increase between 2016 and 2017, was driven by faster real growth in R&D spending (+3,9 %) compared to GDP (+2,3 %). The OECD region did not experience a comparable increase in R&D spending in the two years leading up to the 2008 global financial crisis. In 2018, most OECD countries experienced a worldwide increase in R&D intensity, with the United States, Japan, Germany and Korea accounting for most of the growth.

In some countries, such as Canada and Sweden, R&D spending has remained constant. R&D intensity in the EU-28 crossed the 2 % threshold for the first time, rising from 1,98 to 2,03 %, largely thanks to trends in Germany, the UK and Poland.

Israel and Korea showed the highest level of R&D intensity among OECD countries in 2018 – 4,9 % and 4,5 % of GDP (European Commission Eurostat Science, technology and innovationDataDatabase, 2022).

Table 6
Policies for the formation of an innovative economy in the countries of the world

Target	Policy tool	Expectations	Evidence of Reality	Application
On the demand side	Direct financing of scientifically advanced firms	Cause firms to «effect additionality», investing their own resources in R&D	Rationale for intervention relevance and implementation effectiveness	17 OECD members
	Fiscal entries	Encourage companies to invest in R&D with tax incentives	Growing impact of tax credits on R&D	27 OECD members
	Borg and Rizik breeding schemes	Reduce risk for lenders / investors to make it easier for innovative firms to access external financing	State-subsidized loans and loan guarantees Scanty and mixed evidence	Denmark, Norway, Finland, UK
	Services from the Rozpovsyuzhennya tekhnologii	Expand the dissemination and adoption of existing technologies	Evidence shows importance in low-income countries	USA, Japan, Germany, Canada, Spain and Argentina
	Innovative Procurement Schemes	Drive demand, commercialization, critical mass and access to finance	Evidence is scarce and inconclusive	Australia, Finland, Germany, Sweden
Connection	Clusters	Development of platforms, international and specialized clusters to facilitate collaboration	Significant Evidence	OECD
Normative base	Intellectual Property Rights	Allow innovative entrepreneurs to protect their inventions	Effective protection system before ideas are copied	OECD
	Commodity market	To encourage or discourage competition	Economic effects are heterogeneous	OECD
	Administrative	Enter the markets and grow	Evidence is the annual report Doing Business	OECD
Additional frames	Technology Market	Ministries of Interior and Foreign Affairs	Little evidence on how to access technology	OECD
	Pratsya and Possibilities	Business support, relationships, qualified capital	Firms suffer from a shortage of skilled labor	OECD
	Access to finance	Access to debit, venture capital	Little data	OECD
	Access to the information	ICT, collaboration, public / private investment	Evidence of network knowledge flows	OECD

Source: Guerrero and Urbano (2019)

Therefore, the experience for Ukraine in accounting for the international development of expenditures on science in terms of strategic analytics should be aimed at solving the following tasks (Omelianenko, 2018):

1) conducting an analysis of the best experience of countries in advanced areas of work in the field of science, technology and innovation;

2) preparation of information and analytical materials for the development of strategic government decisions;

3) development of draft regulations in accordance with the requirements of tools, strategies and best practices

4) collection, analysis and preparation of statistical, scientometric and analytical data on science, technology and innovation;

5) development of recommendations, substantive and financial and economic justifications for the inclusion of the country in new international projects in the field of scientific, technical and innovation policy.

According to the generalization of UkrNTEI (2022), practically the entire economy of Ukraine is at a low-tech level according to world criteria due to insignificant and downward volumes of science funding. As a result, the basis of GDP is low-tech foreign economic activity in wholesale and retail trade, agriculture, real estate transactions, transport, etc. The production of high-tech products is growing at the expense of services, but their total share in Ukraine's airborne forces is less than 10 %. At the same time, it is necessary to develop technologies in the most important sectors of national security – military and agricultural.

4.4. Result: Innovative industries

Defense industrial complex. The Center for Innovation and Defense Technologies is necessary for the speedy transformation of the Armed Forces of Ukraine in the context of Russian threats [81]. The creation of modern combat systems in the format of development work requires a lot of time and money, in particular, projects with a significant component of information technology: command and control systems for troops and weapons, reconnaissance equipment, robotic platforms.

At the same time, a critical mass of key technological innovations in the United States and Western European countries appeared primarily due to the coordinating role of the state. Large long-term defense contracts ensured the creation and subsequent rapid growth of a number of high-tech sectors of the economy (primarily the information and communication technology industry) and contributed to the process of accelerated transfer of advanced scientific and technical developments from the military to the civilian sphere.

The release of The Military Balance (2022) shows that advanced military capabilities, supplemented by new technologies, continue to proliferate in an environment of continuous competition. World defense spending in real terms increased by 4,0 % compared to 2018 data (in 2015 prices), the highest increase in ten years. Defense spending in Europe has reached the pre-crisis level of 2008. Concerns about russia's military capabilities and possible actions have played an important role in motivating European states to increase defense spending. In 2021, defense spending in Europe grew by 4,8 % in real terms, the fastest pace recorded for any region in the current year. This marked the seventh consecutive year of growth in real terms in Europe. The increase in 2021 was mainly driven by the UK, but there were also noticeable budget increases in Finland, France, Germany, Greece, Italy and the Netherlands.

Innovations in Ukraine are not yet of decisive importance for the development of the economy of activity and for ensuring the economic stability of the state, for certain sectors, including the military-industrial complex, given its strategic importance and certain information-safe restrictions, it is necessary to develop new approaches to strategic innovation management. In most developed countries of the world, the military-industrial complex has always been the driving force behind innovation. At first, technologies were created for military purposes, and only then they were adapted for other civilian industries.

Ferdman (2020) an analysis of innovative systems, for example, in the military sphere of the advanced countries of the world, primarily NATO member countries, clearly indicates the advantages of a system created and successfully functioning in the US armed forces. This system includes specific research centers and the interspecific Agency for Advanced Defense Research Projects DARPA (Defense Advanced Research Projects Agency). A feature of the latter's activity is the development of interdepartmental, most risky and further prospects (programs of 2–4 yearly research), support for breakthrough research, and bridging the gap between fundamental research and its implementation in the military sphere. On the example of DARPA, analogues have been created in other countries, for example, GDA (France), SASTIND.

The existing model of financing military innovations, due to the structures of Ukroboronprom, cannot compete with open platforms – project offices that accompany innovations from idea to its implementation.

However, in Ukraine, the military-industrial complex has not yet become a platform for relevant developments that form a demand for appropriate organizational innovations. The trend of the last two decades is the growing dependence of the military-industrial complex on various innovative products and solutions from the civilian sectors. This fact creates new challenges for the state and companies in the sector, including in the field of building innovative potential through innovative networks.

Only in 2015, the National Academy of Sciences of Ukraine provided additional funding for the creation of a set of works in the direction of «Scientific research and development on the development of the defense industry». However, these proposals were not taken into account, therefore, the National Academy of Sciences of Ukraine, on its own initiative, without targeted funding, began in 2015 the implementation of the targeted scientific and technical program «Research and development on the problems of increasing the defense capability and security of the state" by reducing other competitive programs and reducing the fund institute salaries. In 2015, UAH 25 million was allocated for this, in 2016 – 30 million, in 2017 – 39, and in 2018 – UAH 50 million (a total of UAH 144 million).

The Academy annually sends annotated reports on completed projects to the National Security and Defense Council, the Ministry of Defense, the General Staff of the Armed Forces of Ukraine, the Central Research Institute of Arms and Military Equipment, Ukroboronprom.

In 2015–2017 institutions of the National Academy of Sciences of Ukraine have already completed the implementation of 44 projects of the Program.

In 2018, the implementation of 20 projects continues and 22 new projects have been launched. In total, among the 86 projects of the Program, 49 are for Ukroboronprom enterprises; 10 – for the HCA of Ukraine; 12 – for the Ministry of Defense and the General Staff; 17 – for implementation at other enterprises and organizations of the defense industry.

Begma and Svergunov (2019) note that without building an innovative system in the defense industry in the state, it is impossible to establish the production of new weapons. It is necessary to restore the sequence of work on the development and creation of modern weapons between the fundamental and exploratory research of the National Academy of Sciences of Ukraine, other branch scientific institutions and higher educational institutions, applied research and development of the relevant institutions of the defense industry and the production process for the manufacture of prototypes of samples and their launch into serial production Responsible for this, according to the Law of Ukraine «On the National Security of Ukraine», is the central executive body that ensures the formation and implementation of the state military-industrial policy.

Researchers [4; 31; 37] note that an important aspect of the investment attractiveness of domestic enterprises is the development of NATO standards by them. Since those states that are interested in their implementation are united in the military-industrial sphere to finance specific projects, it is promising, given the Euro-Atlantic course of Ukraine, to attract investments through the creation of joint ventures with NATO member countries.

One of the important areas of investment and innovation activity for the development of the defense industry should be the creation of technology parks. Such activities should be based on the coordination of actions and the promotion of such key links as science, high education, the national sector of industry, private innovation companies, and regional governments.

According to experts, the Ukrainian municipal-industrial complex is the main beneficiary of the sale of hangers.

The leading positions in the Ukrainian military-industrial complex are traditionally occupied by enterprises controlled by the state through the Ukroboronprom concern, the Ministry of Strategic Industry or the Space Agency. According to the YouControl system, the TOP-3 military-industrial complex companies include: aircraft engine manufacturer Motor Sich, aircraft manufacturing enterprise Antonov, and the state-owned Kiev design bureau Luch, which produces special military equipment (anti-tank and aircraft missiles, missile systems, etc.). The revenue of these companies in 2020 amounted to UAH 11,4 billion, UAH 7,5 billion and UAH 3,8 billion, respectively (Babenko, 2021).

Agro-industrial complex. Agrarian innovations are a type of use of scientific products and knowledge in agriculture, primarily varieties and hybrids of plants, animal breeds, strains of microorganisms, brands and modifications of agricultural machinery, technologies, chemical and biological preparations (vaccines), economic developments (documented methods, recommendations), production technologies and process monitoring, which are expected to result in an increase in production and financial indicators, the optimal use of human, natural and material capital, obtaining a socio-economic and environmental effect and expanded reproduction.

Since the integration of Ukraine into the world economic space, its innovative model for the development of the agrarian economy has been formed, since this process is largely influenced by international competition and the desire of the state to dominate the key segments of the global food market.

The Concept for the Development of Agricultural Science (2011) notes the reasons for its low efficiency, the main of which are: lack of funding for innovation; uncertainty at the state level of priority areas for the development of agricultural science, which leads to a dispersion of research funding; imperfection in the formation of the state order for scientific products and the lack of an effective system for introducing scientific developments in agro-industrial production, etc.

To solve the problem of transition to innovative growth, the Strategy for the Development of the Sphere of Innovation Activities for the Period up to 2030 (2021) proposes a number of effective tools, including agricultural science. In order to ensure the sustainable development of science and innovation, it is necessary to provide, first of all, favorable conditions for the formation and functioning of innovatively active enterprises, the development of a national innovation ecosystem, and the attraction of domestic and foreign investors.

The functional approach proposed in this Strategy is aimed at solving problems hindering innovative development. It was also noted that the agricultural sector can act as an engine of economic growth in the short term, as it has a high potential for modernization, the introduction of new technologies and an increase in the level of processing of its own products, but its prospects are limited. The existing approaches to financing science do not create conditions for the widespread use of innovations by agribusiness. However, the proposed domestic intelligent technological solutions already today help manufacturers to increase the beneficial effect, meet modern market needs and use resources more efficiently.

The annual Forbes AgTech (2021) event named the 25 most innovative startups in agriculture. These include blockchain, vertical farms, unmanned technology, factory automation, and precision farming. Also, according to the results of the event «Introduction of innovative technologies in the agricultural sector: case studies and performance indicators for 2017–2018». The participants recognized that the investments of Ukrainian companies in the introduction of innovative technologies should be about UAH 5 billion – up to $200 million. US per year or 5–10 % of income.

Also, practitioners and experts of the annual Innovative Agricultural Forum AGROIT Forum (Berezniak, 2020) present innovations in the agro-industrial complex as:

– a telemetry system for the implementation of analytics of technological losses, monitoring the state of crops and fields in general;

– innovative solutions for growing and feeding plants;

– innovative advantages of machines;

– complex IT solutions (Agrichain Farm (operational accounting and planning), Agrichain Land (land bank management), Agrichain Scout (monitoring the state of crops), Agrichain Barn (warehouse accounting), Agrichain Report (reporting);

– Agrocontrol platform to increase the profitability of crops and effective development of crops, reducing the negative impact on the environment, optimizing the use of fertilizers, seeds and means of protection, digital monitoring of crops, etc.

An analysis of the state of financing of scientific support for agrarian science in Ukraine shows that it is carried out mainly from budget expenditures. Since the country bears the unreasonable burden of the war and the consequences of the systemic economic crisis, funding is carried out on a residual basis and does not even reimburse socially protected labor costs. The share of total spending on science does not exceed 0,45 %, therefore, science has a social rather than an economic focus and does not have the proper impact on the economy.

NAAS accounts for less than 10 % of science expenditures, and only a relatively preserved technical base, especially land plots, allows continuing scientific and organizational activities to provide its specialized scientific and research institutions.

At present, the problem of expanded financing is being discussed at all levels, in particular, due to self-sufficiency with various forms of commercialization of scientific products, including following the example of the scientific experience of the developed countries of the world.

For now, it is important to maintain the funding for agricultural science planned in the state budget for 2021 in the amount of UAH 662,717 million in general and UAH 952,463 million in special funds, since its reduction, as, unfortunately, already a systemic phenomenon, will lead to losses (Reports of National Academy of Agrarian Sciences of Ukraine, 2022).

Pysarenko, Kuranda and Kvasha (2021) summarized that in order to improve the state of financing of agricultural innovations, it is necessary to:

– increase the volume of investments in scientific and innovative activities, primarily from the state;

– promote the transformation of public procurement into a mechanism to support innovation and create demand for innovation;

– ensure the development of high-tech competitive industries, considering the peculiarities of creating added value along the entire innovation chain (from fundamental science to commercialization, introduction to production and market entry);

– to introduce expanded incentives for the commercialization of the results of scientific and technical activities financed from the state budget, and forging closer links between science and industry;

– provide institutional and financial support for the development of innovative processes and products, innovative infrastructure, assistance in registration of rights and protection of intellectual property;
– promote the entry into foreign markets of goods and services with a high share of gross value added;
– carefully monitor the impact of new mechanisms on innovation.

Thus, the defense and agricultural sectors are most important for the preservation of antiquity and ensuring national security. At the same time, a balance must be maintained between the costs of financing their innovative development, since the costs of the military industry tend to be larger, and the conditions for distributing the costs of the State Budget of Ukraine do not yet allow taking into account all the needs of safely forming industries. Therefore, a balanced state policy is needed to finance and select options for the development of innovations in the field of national development.

4.5. Practical aspects applied to the financial regulation model

Thus, the directions of state regulation of innovations and their implementation have been formed (Table 7).

Table 7
Directions of state regulation of innovations and their implementation

Direction of regulation	Ways to implement state regulation of innovation
Regulatory	Economic and legal methods based on the provisions of the Constitution, relevant laws, internal departmental, administrative orders
Direct financial support	Direct financing by means of the state budget of the process of creating new science-intensive industries and technologies
Incentive fiscal and tax preferential regimes	Introduction of competitive selection for the creation and financing of research programs and research centers;
Institutional Instruments	Centralized provision of state grants and scholarships to leading research centers and scientists
Other tools	Compensation of a bank loan in full or in part in case of its investment in technological changes

Source: Based on Shebanin and Kormyshkin (2019)

At the present stage, it is possible to introduce changes that do not require multibillion-dollar funding, in particular, to determine the priority branches of science for the state in the long term, to focus on those inventions that will help solve national problems, to start a practice when requests for development and research form business, but This research is funded by the state. That is, in the context of increasingly limited state support, scientists must find additional sources of funding and expand the list of paid scientific services [88]. In response to today's challenges, relevant Assistance Centers are being created to coordinate the provision of scientific services and search for mechanisms for organizing cooperation between the participants of such a center – scientific institutions and educational institutions with local authorities and self-government and business entities.

5. Conclusions And Recommendations

Having studied the trends in the state of financing of innovative activity in Ukraine, we can conclude that it is low, because in the period 2010–2021 it did not reach 1 % of the total level of Ukraine’s GDP. The share of innovatively active enterprises in Ukraine in the period of 2012–2018 is approximately 16–17,5 % of the total number of enterprises, when, according to the data presented, there is a tendency to reduce the share of costs for research and development by type of work from 0,75 % in 2010 to 0,41 % in 2020 and the lowest figure for the last year.

The distribution of costs for the implementation of fundamental, applied, scientific and technical developments remains almost stable over the years, and the volume of total funding in 2020 is 210 % of the 2010 level in hryvnias and 62 % in dollars. Empirical and theoretical trend line of the costs of research and development in Ukraine for the period 2010–2020. in hryvnia (left side) and dollars (right side) is shown in fig. 1. For example, in developed world countries this figure is about 70–80 %.

All regressions of indicators in the national currency have a high coefficient of determination, which indicates a uniform change in indicators. However, in dollars, the corresponding models have a low value of determination, which is explained by a significant spread of values. So the devaluation of the hryvnia «evens out» the value of GDP and other indicators.

Calculations confirm that a 1 % increase in controlled exogenous variables in investments, exports, and imports leads to a projected increase in GDP by 0,6 %, while inflation and unemployment (X4, X5) have a negative impact. At the same time, there is no direct connection between GDP growth and the level of research and development funding in Ukraine.

Today, there are propositions of scientists that in order to bring innovation activity in Ukraine to the world level, it is necessary to develop and consolidate at the legislative level a mechanism for preferential taxation of innovative products of enterprises, to increase funding from the state budget for innovation activities of enterprises engaged in development of innovative development, to implement, backed by a legislative framework preferential credit schemes for such enterprises. First of all, it is necessary to develop an appropriate legislative framework for the innovative activities of enterprises and not to interfere with the development of such enterprises.

First of all, science should be financed at a sufficient level. In addition, the policy of state support for innovation should contribute to the development of created products. For non-state enterprises engaged in innovative developments, special support conditions should be created, in particular, direct support for the process of innovation and indirect – tax holidays, a special regime for paying other types of taxes.

In general, government support for innovation should be based on direct and indirect incentive measures in close connection with the needs, requirements and capabilities of the domestic market and its participants, taking into account global trends in this process.

To solve the problem under study, according to the Strategy for Innovative Development of Ukraine until 2030, it is envisaged by implementing program activities in the following areas: creating a favorable regulatory and legal framework for business entities engaged in innovative activities; development of innovative infrastructure, methodological consulting support, expansion of ties between domestic scientists and inventors with foreign enterprises.

It is necessary to strengthen the directions of dissemination of agro-innovations by supporting the IT industry; development of educational cooperation between scientific institutions, agricultural enterprises and the state; promoting the development of industries where the introduction of innovations is accompanied by the least risks. It is advisable to adopt foreign experience in terms of the state strategy for regulating innovation activity, depending on the phase of economic development and budgetary possibilities.

The above proposals for a harmonized correction of legislation in the field of ensuring national security and building up innovative potential will make it possible to solve a significant number of financial, socio-economic and environmental problems of Ukraine, bring it to an equal level of international economic cooperation, balancing foreign trade operations, and determine Ukraine's place in the international division of labor. One of the important results will be to reduce the risk of military conflicts and the dependence of the domestic economy on global financial institutions.

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