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TAX INCENTIVES FOR INNOVATION IN THE CONTEXT OF MACROECONOMIC STABILITY: AN ANALYSIS OF CAUSALITY

Abstract. *The article deals with the topical issue of R&D tax incentives and their impact on the level of innovation development and macroeconomic stability. The research is based on causality analysis and estimation of the strength, time lags and directions of mutual influence of R&D tax incentives and macro indicators. Systematization literary sources and approaches for solving this problem indicates that R&D tax incentives are studied in fragments in the context of macroeconomic stability. The research's main purpose is to improve the methodological bases of substantiation of the choice of relevant instruments of innovation stimulation considering causal relations of R&D tax incentives and macro indicators. The paper presents the results of dynamic analysis of R&D tax incentives in 13 European countries, for which OECD statistics for 2007-2017 are freely available. The significance, strength, and nature of the relationship between these indicators and the following macro indicators are determined: the level of the country's innovation development, the share of investment in GDP (in general and in the corporate sector in particular), net international investment position, the share of the business sector in the cost structure of R&D. Pearson and Spearman correlation coefficients were calculated depending on the variable subordination to the law of normal distribution (verified by the Shapiro – Wilk test) on the admissible calculation interval taking into account time lags from 0 years to 3 years. The causality of the studied indicators was established using the Granger causality test. The calculations are important for the prioritization of instruments for the implementation of innovation support. The highest priority should be given to the establishment of tax incentives for R&D, as this tool's impact on all studied macro indicators in most countries was direct. Its effect was manifested in the shortest possible time (with a lag of 0-3 years). The second priority should be given to setting hidden rates of business tax subsidies on R&D, as this indicator's impact on most of the studied indicators was statistically significant and direct with a time lag of 0–3 years. The paper substantiates the inefficiency of direct public financial support, as the impact of this indicator on most of the analyzed macro-indicators was reversed with a lag of 0–2 years. Thus, it is more expedient for the state to help entrepreneurs by providing tax benefits to provide innovation development and macro stability than through direct reimbursement of costs. Moreover, lag regression models were built for those countries where identified links were the most important (Belgium, Denmark, the Netherlands, and the Czech Republic). They take into account inflation rates and interest rates on long-term liabilities and the number of labour resources in the country as control variables.*

Keywords: causal relations, Granger causality test, innovation, investment position, macro indicators, macroeconomic stability, R&D tax expenditure, R&D, tax incentives, tax subsidies.

Introduction. The importance of macroeconomic stability in any country is beyond doubt. However, in the context of global challenges of an economic nature and, for example, under the influence of the coronavirus pandemic, indicators of macroeconomic stability in Ukraine and Azerbaijan show lagging behind targets compared to developed European countries. Under such conditions, we consider tax incentives for innovation to be relevant in increasing macroeconomic stability.

Indicators of tax and fiscal stimulus are an important component of fiscal policy to ensure the innovative development of the world, as research and development (R&D) provide both private and social effect (and many times greater than private) (Jones and Williams, 1998; Czyżewski et al., 2019; Miśkiewicz & Wolniak, 2020; Baranovskyi, 2020), which leads to government intervention in the field of innovation. Besides, tax incentives are tools to stimulate R&D in the private sector directly.

As tax and budget-investment incentives for innovation have become widespread in developed EU countries but are currently underdeveloped in Ukraine, Azerbaijan, and many other post-Soviet countries, this issue requires further fundamental and applied research.

The purpose of the article is to improve the methodological basis for substantiating the choice of relevant instruments to stimulate innovation development, considering the areas of mutual influence of tax and budget-investment stimulation of innovation development on many indicators of macroeconomic growth.

Literature Review. Several scholars have studied some aspects of R&D tax incentives. Bloom et al. (2002) examined the impact of fiscal stimulus on R&D investment by estimating the econometric model of R&D investment based on tax changes and R&D expenditures in nine OECD countries over 19 years (1979–1997) and conclude that R&D tax incentives would increase their intensity. Scientists empirically confirm that a 10% drop in R&D costs stimulates a little more than 1% growth in R&D in the short term and a little less than 10% growth in R&D in the long run. Assessing the effectiveness of fiscal stimulus R&D is also covered in the work of Hall and Reenen (2000), Lee (2011), Hrytsenko et al (2018), Kuznetsova and Pohorelenko (2020), Tkachenko et al. (2019) and others.

Fazio et al. (2020) substantiated the impact of state tax credits for R&D on quantitative and qualitative entrepreneurship indicators, pointing to the potential of state tax crediting of innovations to stimulate entrepreneurship. Klemm (2009) analyzes various tax incentives for business investment, positioning tax benefits in response to tax competition - the main driver of tax reforms. It provides theoretical and empirical conclusions on the pros and cons of tax benefits and more. Tassey (1996) compares tax incentives for R&D with direct public funding, justifying public policy options in the field of R&D.

Corchuelo and Martínez-Ros (2010) characterized the benefits that firms receive from fiscal R&D incentives and the overall impact of this type of tool on innovation performance. Emphasizing that tax incentives are not widespread and rarely used by firms, researchers found that large innovative firms are more likely to use tax incentives (and significantly affect this). In contrast, small and medium-sized ones face particular barriers to their use.

Hodzic and Becic (2016) examined the tax incentives for R&D of large Croatian companies. They emphasized the need to review legislation to remove obstacles created by bureaucratic barriers and over-regulation in the process of tax incentives for R&D (primarily as a means of reducing the income tax base). Further, encourage the production of new goods and services, create new jobs, and stimulate economic growth. Cappelen et al. (2010) investigated the Norwegian R&D tax credit scheme, which encourages a large number of firms to invest more in R&D and has a positive effect, including for small firms with little research and development experience. FurKoga (2003) drew attention to tax incentives' peculiarities for large and small, and medium-sized enterprises.

Li and Du (2016) view tax incentives for firm research as an important tool for governments seeking to address the «market failure» of R&D investment. The authors use China's example to study the

impact of adjusting costs on the incentive effects of R&D tax policy, arguing that R&D tax incentives have a positive impact on the level of investment in innovation. Still, the effect gradually decreases with increasing adjustment costs. Guceri (2016) assessed the impact of R&D tax policy based on the experience of R&D tax incentives for innovative firms in the US, UK, France, China and Korea (Guceri, 2016, Guceri and Liu, 2015).

Tiutiunyk et al. (2019) investigate innovations in the management of tax gaps in the economy and estimate the volume of tax gaps in the economy in the country's foreign economic activity as one of the tools for minimizing tax liabilities.

Particular attention was paid to developing countries: what incentives could be used in them; which makes them useful; how much they should cost (James, 2013).

However, despite the available scientific achievements, tax incentives in the field of R&D were studied in fragments. Therefore, it requires consideration of the latest trends and the solution of existing problems, which caused the urgency of further research.

Methodology and research methods. This study applied the methods of correlation and regression analysis using the STATA software package for the sample from 13 European countries for 2007-2017 (limited calculations in 2017 due to the availability of information on open information portals of The Organization for Economic Co-operation and Development, the World Bank, EU Statistical Office) to confirm the hypothesis on the impact of the tax and budget-investment instruments of the innovation stimulation on the innovation and investment development of the country.

The nature of the distribution of the studied indicators was assessed using the Shapiro-Wilk test (Shapiro and Wilk, 1965). These results allowed choosing the calculating method of the correlation coefficient: Pearson – for indicators subject to the law of normal distribution (Pearson, 1896), or Spearman – for indicators that do not obey normal distribution (Spearman, 1987). The strength and nature of the relationship between the indices were established through a correlation analysis. It revealed the duration of time lags, after which this relationship is the most statistically significant. Granger causality test (Granger, 1969, Lopez and Weber, 2017, Tastan, 2015) was used to assess the relationship between tax and budget-investment instruments of the innovation stimulation and macro indicators of innovation investment development.

There are lag models of linear regression (Strielkowski & Höschle, 2016; Simionescu et al., 2017; Vovchak et al., 2018; Savchenko et al., 2019) to determine the impact of the tax and budget-investment instruments on innovation and investment development in certain countries, where it was the most significant (Belgium, Denmark, the Netherlands, and the Czech Republic).

Results. To conduct this study, a sample of 13 European countries was formed, for which OECD statistics for 2007-2017 are available in free access for all studied indicators of tax incentives.

Actual tax subsidy rates on R&D expenditures (Table 1) are one of the indicators of tax incentives calculated by the Organization for Economic Co-operation and Development (OECD) for OECD member countries and individual non-OECD countries (Warda, 2001; OECD Science, Technology and R&D Statistics, OECD R&D Tax Incentive Database).

Table 1. Implied tax subsidy rates on R&D expenditures, %

Country	The firm's size	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	SME	0,10	0,13	0,15	0,15	0,15	0,15	0,16	0,16	0,16	0,16	0,16
	LF	0,10	0,13	0,15	0,15	0,15	0,15	0,16	0,16	0,16	0,16	0,16
The Czech Republic	SME	0,27	0,23	0,21	0,20	0,20	0,20	0,20	0,21	0,21	0,21	0,21
	LF	0,27	0,23	0,21	0,20	0,20	0,20	0,20	0,21	0,21	0,21	0,21
Denmark	SME	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01
	LF	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01	-0,01
France	SME	0,21	0,43	0,43	0,43	0,44	0,44	0,45	0,45	0,45	0,43	0,43
	LF	0,21	0,43	0,43	0,43	0,44	0,44	0,45	0,45	0,45	0,43	0,43

Continued Table 1

Hungary	SME	0,24	0,24	0,24	0,16	0,11	0,11	0,26	0,25	0,25	0,25	0,22
	LF	0,24	0,24	0,24	0,22	0,22	0,22	0,36	0,35	0,35	0,35	0,22
Ireland	SME	0,21	0,21	0,26	0,26	0,25	0,27	0,26	0,27	0,29	0,29	0,29
	LF	0,21	0,21	0,26	0,26	0,25	0,27	0,26	0,27	0,29	0,29	0,29
Italy	SME	0,12	0,12	0,12	-0,02	-0,02	-0,02	-0,02	-0,02	0,04	0,04	0,09
	LF	0,12	0,12	0,12	-0,02	-0,02	-0,02	-0,02	-0,02	0,04	0,04	0,09
Lithuania	SME	0,00	0,31	0,45	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31
	LF	0,00	0,31	0,45	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31
The Netherlands	SME	0,24	0,24	0,29	0,29	0,29	0,28	0,27	0,26	0,26	0,31	0,31
	LF	0,07	0,07	0,09	0,09	0,10	0,12	0,14	0,15	0,15	0,15	0,15
Portugal	SME	0,28	0,28	0,41	0,41	0,41	0,41	0,41	0,40	0,39	0,39	0,39
	LF	0,28	0,28	0,41	0,41	0,41	0,41	0,41	0,40	0,39	0,39	0,39
Slovenia	SME	0,04	0,04	0,04	0,08	0,08	0,20	0,19	0,19	0,19	0,19	0,21
	LF	0,04	0,04	0,04	0,08	0,08	0,20	0,19	0,19	0,19	0,19	0,21
Spain	SME	0,39	0,35	0,35	0,35	0,35	0,35	0,35	0,35	0,34	0,33	0,33
	LF	0,39	0,35	0,35	0,35	0,35	0,35	0,35	0,35	0,34	0,33	0,33
The United Kingdom	SME	0,11	0,18	0,18	0,18	0,23	0,28	0,28	0,28	0,29	0,29	0,27
	LF	0,10	0,11	0,11	0,11	0,09	0,09	0,09	0,09	0,10	0,10	0,10

Note: SME – small and medium enterprises; LF – large firm, subjects of large business

Sources: developed by the authors based on (OECD Science, Technology and R&D Statistics, 2007–2017).

In some countries, the hidden tax subsidy rates on R&D costs do not depend on the firm's size (Belgium, the Czech Republic, Denmark, France, Ireland, Italy, Lithuania, Portugal, Slovenia, Spain). In the United Kingdom and the Netherlands, rates for small and medium-sized enterprises are higher than for large enterprises. In contrast, in Hungary, large enterprises' hidden tax subsidy rates are higher than for small and medium-sized enterprises. Under comparing the tax subsidy's hidden rates on R&D expenditures for small and medium-sized enterprises for 2007-2017, it should be noted that the highest rates since 2008-2009 have been stable in France, Portugal, Spain and Lithuania. In turn, Italy had the lowest negative figures from 2009 to 2014. The situation is similar in Denmark, but with a constant negative rate. At the same time, other countries are characterized by ups and downs. Relatively stable indicators also occur in Belgium, the Czech Republic and France. In 2009, there is a rise in this indicator in most countries. Still, for other periods, a clear general trend is not observed due to the individual characteristics of developing this sample's countries. Accordingly, this study compares the hidden tax subsidy rates on R&D expenditures for large enterprises for 2007-2017. The highest rates are in France, Portugal and Spain. The lowest – in Italy, Denmark, etc. In most countries, the quality is relatively stable in dynamics, except for Hungary, Slovenia, the Netherlands, Italy and others. There are declines and rises in the change of the studied indicator.

Indicators of R&D tax incentives also include R&D tax expenditures and direct government financing of business sector R&D expenditures (R&D tax expenditure and direct government funding of BERD (Business enterprise R&D expenditure)). This set of indicators (Tables 2-3), similarly to the previous one, reflects the level and structure of central government support for the development of R&D research and direct financing of business sector R&D expenditures in OECD and eleven non-OECD countries. Estimates of the value of R&D tax benefits are combined with data on direct funding of business sector R&D expenditures (OECD, R&D tax expenditure and direct government funding of BERD).

Table 2. Indirect government support through tax breaks on R&D, % of GDP

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	0,05	0,08	0,15	0,18	0,19	0,20	0,23	0,27	0,33	0,30	0,30
The Czech Republic	0,03	0,03	0,03	0,03	0,05	0,05	0,06	0,05	0,06	0,05	0,05

Continued Table 2

Denmark	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,02	0,02	0,02
France	0,10	0,23	0,26	0,28	0,27	0,28	0,28	0,28	0,29	0,28	0,28
Hungary	0,16	0,18	0,17	0,17	0,17	0,12	0,14	0,16	0,15	0,09	0,06
Ireland	0,08	0,08	0,13	0,13	0,15	0,16	0,23	0,28	0,27	0,25	0,15
Italy	0,02	0,03	0,03	0,00	0,00	0,01	0,00	0,00	0,05	0,08	0,16
Lithuania	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,02	0,03	0,02
The Netherlands	0,07	0,07	0,11	0,13	0,14	0,13	0,15	0,15	0,13	0,17	0,16
Portugal	0,08	0,08	0,10	0,09	0,10	0,09	0,09	0,10	0,11	0,11	0,12
Slovenia	0,04	0,04	0,03	0,05	0,05	0,09	0,09	0,10	0,12	0,11	0,11
Spain	0,03	0,03	0,03	0,03	0,02	0,03	0,03	0,03	0,03	0,03	0,04
The United Kingdom	0,05	0,06	0,07	0,07	0,07	0,08	0,09	0,16	0,20	0,22	0,21

Sources: developed by the authors based on (OECD Science, Technology and R&D Statistics, R&D tax expenditure and direct government funding of BERD, 2007-2017).

Table 3. Direct government funding of BERD, % of GDP

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	0,07	0,08	0,09	0,11	0,09	0,09	0,08	0,09	0,09	0,08	0,06
The Czech Republic	0,11	0,10	0,11	0,11	0,12	0,12	0,11	0,10	0,08	0,06	0,08
Denmark	0,04	0,05	0,06	0,06	0,05	0,05	0,03	0,04	0,05	0,05	0,04
France	0,12	0,15	0,12	0,12	0,11	0,11	0,12	0,11	0,13	0,11	0,12
Hungary	0,05	0,04	0,10	0,10	0,11	0,13	0,18	0,16	0,19	0,07	0,13
Ireland	0,04	0,05	0,05	0,05	0,06	0,07	0,07	0,06	0,04	0,04	0,04
Italy	0,04	0,04	0,04	0,04	0,05	0,05	0,05	0,04	0,04	0,03	0,03
Lithuania	0,01	0,01	0,01	0,01	0,00	0,01	0,01	0,01	0,01	0,00	0,00
The Netherlands	0,02	0,02	0,03	0,06	0,04	0,02	0,02	0,02	0,02	0,02	0,02
Portugal	0,02	0,02	0,04	0,03	0,03	0,05	0,06	0,05	0,03	0,02	0,03
Slovenia	0,07	0,06	0,14	0,22	0,27	0,27	0,25	0,14	0,07	0,05	0,07
Spain	0,11	0,13	0,12	0,12	0,10	0,09	0,07	0,06	0,06	0,06	0,06
The United Kingdom	0,07	0,07	0,08	0,09	0,10	0,08	0,09	0,10	0,09	0,09	0,09

Sources: developed by the authors based on (OECD Science, Technology and R&D Statistics, R&D tax expenditure and direct government funding of BERD, 2007-2017).

The largest indirect government support values through tax breaks on R&D (in% of GDP) are in France, Belgium, and the United Kingdom, and the lowest in Denmark, Lithuania and Spain. Hungary, France, and the United Kingdom are in the lead in the direct public financing of business sector R&D expenditures (in % of GDP). The lowest values are shown by Lithuania, Italy, the Netherlands, and Portugal.

Thus, because of the analysis of tax incentives for R&D from 2007 to 2017, significant differences in fiscal policy approaches to ensure innovative development in different countries were revealed. They identify those who hold the highest and lowest positions in the hidden rate of tax subsidies on R&D expenditures, indirect government support through tax benefits, and direct government funding of business sector R&D expenditures. Accordingly, European countries' experience in tax incentives for R&D is relevant for Ukraine, given the growing role of innovation in various economic activity areas and its impact on economic growth and investment attractiveness of the state as a whole.

It is appropriate to examine how the above indicators of R&D tax incentives affect, in particular the hidden tax subsidy rate on R&D expenditures for small and medium enterprises and large enterprises, tax benefits on R&D (indirect government support) and direct state funding of expenditures business sector on R&D, on:

- the amount of research and development costs funded by the business sector;
- the amount of investment in the corporate sector;
- the share of investment in GDP;

—   on the indicator of net international investment position, etc.

Table 4 provides data on research and development expenditures financed by the business sector (Intramural R&D expenditure (GERD) by the source of funds: Business enterprise sector).

Table 4. Intramural R&D expenditure (GERD) funding by business enterprise sector, % of GERD

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	61,4	61,0	58,7	57,6	60,2	60,6	60,6	60,0	58,6	61,0	63,5
The Czech Republic	47,2	45,0	39,8	40,8	37,7	36,4	37,6	35,9	34,5	39,5	39,3
Denmark	61,0	61,5	62,1	61,1	61,2	59,9	59,0	59,0	59,1	59,0	58,5
France	52,3	50,8	52,3	53,5	55,0	55,3	55,1	55,7	56,0	56,0	56,1
Hungary	43,9	48,3	46,4	47,4	47,5	46,9	46,8	48,3	49,7	56,4	52,7
Ireland	49,5	48,8	52,1	52,2	48,9	50,2	52,6	52,2	48,7	49,0	52,1
Italy	42,0	45,9	44,2	44,7	45,1	44,3	45,2	47,3	50,0	52,1	53,7
Lithuania	32,8	29,3	30,8	32,4	28,2	26,5	27,5	32,7	28,5	39,0	35,4
The Netherlands	48,8	47,0	45,1	48,0	51,1	51,6	51,1	51,1	48,6	52,0	51,6
Portugal	47,0	48,1	43,9	43,9	44,7	46,0	42,3	41,8	42,7	44,4	46,5
Slovenia	58,3	62,8	58,0	58,4	61,2	62,2	63,8	68,4	69,2	69,2	63,1
Spain	45,5	45,0	43,4	43,0	44,3	45,6	46,3	46,4	45,8	46,7	47,8
The United Kingdom	46,0	45,4	44,5	44,0	45,9	45,6	46,2	48,0	49,0	51,8	53,7

Sources: developed by the authors based on (EU Statistical Office Data, Intramural R&D expenditure by source of funds, 2007-2017).

Table 5 presents the investment by Corporate sector, % of GFCF, in selected countries. The GFCF (Gross fixed capital formation), the share of which represents the corporate sector's investment, means gross fixed capital, which in the general meaning is identified with the category of investment.

Table 5. Investment by Corporate sector, % of GFCF

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	63,42	63,90	63,23	62,76	64,71	64,37	64,83	64,00	65,37	66,15	66,34
The Czech Republic	64,92	63,58	58,46	59,39	64,26	66,54	67,61	65,73	63,55	67,90	67,21
Denmark	54,90	57,06	60,40	57,39	57,40	58,17	60,60	60,34	61,94	63,32	62,56
France	53,35	54,35	53,01	53,57	54,97	55,21	55,26	56,71	58,28	58,74	58,75
Hungary	61,04	64,17	62,34	62,19	67,36	65,69	65,06	62,33	56,32	66,74	62,54
Ireland	42,69	41,93	57,53	60,81	69,41	78,56	77,29	79,37	85,59	89,17	87,97
Italy	50,10	50,20	46,82	49,29	51,11	51,62	51,93	54,33	55,40	56,51	57,72
Lithuania	68,01	64,31	55,38	51,01	56,30	59,73	60,43	61,41	59,82	62,18	63,59
The Netherlands	50,30	48,06	48,29	51,90	54,48	55,47	57,98	54,97	61,72	54,07	54,71
Portugal	59,65	60,43	58,4	52,21	58,32	60,77	63,88	65,45	65,05	68,63	68,56
Slovenia	62,26	62,14	58,22	55,44	59,52	59,58	60,28	55,15	55,43	61,36	62,75
Spain	51,88	52,08	47,72	49,75	55,73	63,51	69,03	70,94	69,99	73,02	72,11
The United Kingdom	60,91	59,51	58,17	58,26	59,40	61,57	61,82	60,75	61,47	62,09	61,32

Sources: developed by the authors based on (OECD Data, Investment by Corporate sector, 2007-2017).

Table 6 demonstrates data on the share of total investment in GDP in the selected countries. This indicator shows investment for the general economy, government, business, and households as a share of GDP used for gross investment (GFCF, expressed as a percentage of GDP for government, business and households).

Table 6. Total investment share of GDP, %

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	23,29	24,12	22,78	22,12	23,01	22,96	22,17	22,81	22,96	23,21	23,11

Continued Table 6

The Czech Republic	29,49	28,96	27,05	26,91	26,45	25,91	25,06	25,13	26,47	24,93	24,77
Denmark	23,51	22,94	20,17	18,11	18,16	18,78	19,05	19,16	19,85	21,02	21,19
France	23,18	23,60	22,07	22,11	22,42	22,46	22,04	21,82	21,50	21,82	22,48
Hungary	23,73	23,37	22,69	20,23	19,65	19,25	20,84	22,10	22,28	19,66	22,23
Ireland	28,69	24,78	21,09	17,54	16,60	19,61	18,56	20,64	24,06	35,63	31,39
Italy	21,66	21,28	20,11	20,02	19,71	18,31	17,20	16,72	16,94	17,17	17,48
Lithuania	28,58	26,04	17,86	16,91	18,51	17,36	18,45	18,89	19,62	19,86	19,99
The Netherlands	23,29	22,12	21,31	19,70	20,14	18,76	18,36	17,59	22,11	20,00	20,14
Portugal	23,54	22,55	23,23	20,73	21,49	22,41	23,54	23,82	23,78	25,34	24,95
Slovenia	22,51	22,85	21,20	20,57	18,42	15,82	14,75	15,03	15,52	15,49	16,78
Spain	28,65	29,44	24,13	21,08	19,94	19,03	19,63	19,11	18,65	17,39	18,32
The United Kingdom	29,86	27,84	23,11	21,79	20,02	18,53	17,37	17,78	18,01	17,96	18,66

Sources: developed by the authors based on (EU Statistical Office Data, Investment share of GDP by institutional sectors, 2007-2017).

Table 7 gives the indicators of the net international investment position of the studied countries. Notably, the net global investment position is a statistical indicator that at some point in time shows the difference between external financial assets and liabilities of the economy as a percentage of GDP. It could be positive or negative. The net international investment position reflects the country's net financial position (assets fewer liabilities) relative to the rest of the world. It allows analyzing the country's external work's stock-flow, based on Eurostat data on the balance of payments statistics.

Table 7. Net international investment position, % of GDP

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	33,70	42,90	58,20	56,30	51,40	40,80	43,20	44,80	45,20	54,50	56,80
The Czech Republic	-36,40	-38,10	-43,90	-46,00	-45,20	-45,90	-41,40	-36,60	-32,90	-26,90	-25,00
Denmark	-5,80	-5,10	0,90	12,80	27,80	36,10	37,20	43,30	33,40	52,60	55,40
France	-8,90	-13,80	-14,80	-9,30	-8,70	-12,80	-16,60	-15,60	-12,90	-13,00	-16,60
Hungary	-90,60	-100,40	-113,40	-106,70	-104,20	-92,20	-82,20	-80,40	-67,90	-59,60	-55,10
Ireland	-31,40	-95,30	-115,70	-113,50	-139,30	-137,80	-133,40	-164,70	-198,40	-171,70	-167,20
Italy	-21,10	-21,60	-22,30	-20,10	-18,20	-23,00	-23,30	-21,00	-19,30	-11,90	-7,70
Lithuania	-56,40	-52,70	-61,10	-60,00	-53,60	-54,30	-50,60	-46,80	-43,60	-42,90	-37,90
The Netherlands	-14,90	-8,00	1,40	11,00	20,10	26,70	30,70	48,00	48,90	61,40	59,40
Portugal	-90,10	-97,80	-110,70	-107,20	-104,10	-119,30	-120,20	-123,80	-118,90	-110,50	-110,40
Slovenia	-25,50	-39,40	-40,60	-43,10	-39,80	-44,00	-39,30	-38,40	-31,20	-28,90	-24,20
Spain	-85,30	-85,40	-97,60	-91,00	-93,80	-88,90	-92,80	-95,90	-88,90	-85,50	-85,50
The United Kingdom	-8,80	8,90	-16,20	-7,90	-11,60	-28,10	-17,80	-22,80	-22,70	0,30	-10,00

Sources: developed by the authors based on (EU Statistical Office Data, Net international investment position, 2007-2017).

Let's determine the strength and nature of the relationship between the indicators of tax incentives for R&D in different countries, calculating the correlation coefficients, taking into account time lags in 1, 2 and 3 years. Before that, it is necessary to check whether the studied indicators are subject to the normal distribution, using the Shapiro-Wilk test (Table 8).

Table 8. The results of the Shapiro-Wilk test on the subordination of R&D tax incentives to the law of normal distribution

	W	V	z	Prob>z		W	V	z	Prob>z
	Belgium					*The Czech Republic*			
TSR1	0.59580	6.544	4.080	0.00002*	TSR1	0.66609	5.406	3.579	0.00017*
TSR2	0.59580	6.544	4.080	0.00002*	TSR2	0.66609	5.406	3.579	0.00017*

Continued Table 8

TI	0.95196	0.778	-0.437	0.66911	TI	0.85877	2.287	1.594	0.05551
GF	0.97954	0.331	-1.793	0.96353	GF	0.91680	1.347	0.545	0.29286
	Denmark					*France*			
TSR1	-	-	-	-	TSR1	0.31343	11.12	5.617	0.00000*
TSR2	-	-	-	-	TSR2	0.31343	11.12	5.617	0.00000*
TI	0.82451	2.841	2.058	0.01977*	TI	0.56694	7.012	4.267	0.00001*
GF	0.90145	1.596	0.869	0.19251	GF	0.89352	1.724	1.020	0.15384
	Hungary					*Ireland*			
TSR1	0.69708	4.905	3.333	0.00043*	TSR1	0.88961	1.787	1.092	0.13752
TSR2	0.74041	4.203	2.956	0.00156*	TSR2	0.88961	1.787	1.092	0.13752
TI	0.85219	2.393	1.689	0.04558*	TI	0.91538	1.370	0.577	0.28200
GF	0.95256	0.768	-0.459	0.67675	GF	0.77652	3.618	3.618	0.00462*
	Italy					*Lithuania*			
TSR1	0.96823	0.514	-1.117	0.86810	TSR1	0.93242	1.094	0.162	0.43582
TSR2	0.96823	0.514	-1.117	0.86810	TSR2	0.93242	1.094	0.162	0.43582
TI	0.73654	4.266	2.991	0.00139*	TI	0.95126	0.789	-0.413	0.66003
GF	0.92125	1.275	0.442	0.32922	GF	0.87431	2.035	1.353	0.08804
	The Netherlands					*Portugal*			
TSR1	0.99319	0.110	-3.305	0.99953	TSR1	0.53758	7.487	4.448	0.00000*
TSR2	0.96039	0.641	-0.761	0.77656	TSR2	0.53758	7.487	4.448	0.00000*
TI	0.86550	2.178	1.492	0.06784	TI	0.92560	1.205	0.337	0.36809
GF	0.69557	4.929	3.346	0.00041	GF	0.89002	1.781	1.084	0.13917
	Slovenia					*Spain*			
TSR1	0.75451	3.975	2.823	0.00238*	TSR1	0.78368	3.502	2.528	0.00574*
TSR2	0.75451	3.975	2.823	0.00238*	TSR2	0.78368	3.502	2.528	0.00574*
TI	0.88465	1.868	1.179	0.11913	TI	0.99386	0.099	-3.437	0.99971
GF	0.84585	2.496	1.778	0.03767*	GF	0.88477	1.866	1.177	0.11956
	The United Kingdom								
TSR1	0.84942	2.438	1.729	0.04194*					
TSR2	0.99112	0.144	-2.962	0.99847					
TI	0.79815	3.268	2.370	0.00889*					
GF	0.93510	1.051	0.089	0.46469					

Notes: * – beyond the normal distribution; TSR1– the hidden rate of the tax subsidy for R&D expenditures for small and medium enterprises; TSR2– the hidden rate of the tax subsidy on R&D expenses for large business entities; TI – tax incentives for R&D (indirect government support); GF – direct public funding of business sector expenditures on R&D.

Sources: developed by the authors.

Accordingly, to determine the strength and nature of the relationship between the indicators that obey the normal distribution law (Shapiro-Wilk test result> 0.05), the Pearson correlation coefficient was calculated. Instead, to identify the relationship between indicators that do not obey the normal distribution law (Shapiro-Wilk test result <0.05), the Spearman correlation coefficient was calculated. Calculations are performed in the STATA software package. Tables 9-12 present the results of the analyses.

Table 9. Identifying the strength and nature of the relationship between R&D tax incentives and the share of R&D expenditures financed by the business sector (considering time lags for the period from 2007 to 2017)

Indicator	Time lag, years				Time lag, years			
	0	1	2	3	0	1	2	3
	Belgium				*The Czech Republic*			
TSR_SME	0.3401	0.2195	0.5510	0.8094	-0.2182	0.4364	0.9129	0.5491
TSR_LF	0.3401	0.2195	0.5510	0.8094	-0.2182	0.4364	0.9129	0.5491
TI	0.0360	0.3666	0.7873	0.7218	-0.7833	-0.6001	-0.3849	0.0095
GF	-0.9215	-0.1473	0.6211	0.4052	0.0593	-0.1706	-0.5281	-0.7380

Continued Table 9

		Denmark				*France*		
TSR_SME	-	-	-	-	-0.0634	0.4436	0.8872	0.9446
TSR_LF	-	-	-	-	-0.0634	0.4436	0.8872	0.9446
TI	-0.8051	-0.8051	-0.6750	-0.6504	0.7545	0.7904	0.9102	0.7545
GF	0.5567	0.1883	-0.0651	-0.0717	-0.7195	-0.5894	-0.4917	-0.4701
		Hungary				*Ireland*		
TSR_SME	0.1473	0.7979	0.7274	0.3805	0.2440	0.0454	-0.3148	-0.0089
TSR_LF	0.0000	0.7509	0.7660	0.5006	0.2440	0.0454	-0.3148	-0.0089
TI	-0.3810	-0.3571	-0.6429	-0.5476	0.1194	-0.1420	-0.3863	0.0422
GF	0.0464	0.4438	0.7057	0.8522	0.5988	0.3593	-0.1317	-0.6228
		Italy				*Lithuania*		
TSR_SME	0.0543	-0.1480	-0.3902	-0.6994	-0.1388	0.1847	-0.0752	-0.2623
TSR_LF	0.0543	-0.1480	-0.3902	-0.6994	-0.1388	0.1847	-0.0752	-0.2623
TI	0.5476	0.4286	-0.0952	-0.8095	0.5062	0.6382	0.1600	-0.1755
GF	-0.6552	-0.4063	0.4440	0.6705	-0.4318	-0.2649	-0.2295	-0.4084
		The Netherlands				*Portugal*		
TSR_SME	0.3547	0.6635	0.6889	0.3282	-0.0652	-0.3712	-0.3546	-0.4124
TSR_LF	0.6633	0.6485	0.5449	0.3592	-0.0652	-0.3712	-0.3546	-0.4124
TI	0.6664	0.8244	0.7824	0.4747	-0.2837	0.1580	0.3773	0.0520
GF	-0.4051	-0.1964	-0.2455	-0.0614	-0.6472	-0.8634	-0.2703	0.4140
		Slovenia				*Spain*		
TSR_SME	0.3212	0.7451	0.8078	0.8513	-0.7011	-0.7638	-0.5774	-0.5774
TSR_LF	0.3212	0.7451	0.8078	0.8513	-0.7011	-0.7638	-0.5774	-0.5774
TI	0.8432	0.8265	0.7392	0.6014	0.5433	-0.0293	-0.3038	-0.1250
GF	-0.7545	-0.1198	0.5988	0.8982	-0.8017	-0.9079	-0.8469	-0.7010
		The United Kingdom						
TSR_SME	0.5279	0.9266	0.9512	0.9512				
TSR_LF	-0.1767	-0.2761	-0.4809	-0.7275				
TI	0.9524	0.9762	0.9762	0.9762				
GF	0.2883	0.5095	0.7211	0.7533				

Notes: TSR_SME – the hidden rate of tax subsidy on R&D costs for small and medium enterprises; TSR_LF – the hidden rate of tax subsidy on R&D costs for large businesses; TI – tax incentives for R&D (indirect government support); GF – direct government funding of the business sector's R&D expenditures.

Sources: developed by the authors.

Table 10. The identification of the strength and nature of the relationship between indicators of tax incentives for R&D and the amount of investment in the corporate sector (considering time lags for the period from 2007 to 2017)

Indicator	Time lag, years				Time lag, years			
	0	1	2	3	0	1	2	3
		Belgium				*The Czech Republic*		
TSR_SME	0.6198	0.5455	0.9129	0.8045	0.2182	-0.1091	-0.1826	-0.5108
TSR_LF	0.6198	0.5455	0.9129	0.8045	0.2182	-0.1091	-0.1826	-0.5108
TI	0.7340	0.8156	0.9291	0.8405	0.6963	0.8183	0.6113	0.3584
GF	-0.4995	0.2055	0.4928	0.2902	-0.3648	-0.1973	0.0478	-0.0221
		Denmark				*France*		
TSR_SME	-	-	-	-	-0.0630	0.4410	0.9449	0.9636
TSR_LF	-	-	-	-	-0.0630	0.4410	0.9449	0.9636
TI	0.9048	0.9048	0.8383	0.8503	0.7619	0.8333	0.8571	0.8571
GF	-0.2208	-0.2131	-0.4433	-0.3080	-0.2819	-0.4414	-0.3880	-0.5546
		Hungary				*Ireland*		
TSR_SME	-0.3192	-0.4297	-0.1818	0.5647	0.9382	0.8777	0.8968	0.8961
TSR_LF	-0.1565	-0.5006	-0.2347	0.5006	0.9382	0.8777	0.8968	0.8961
TI	-0.1190	0.0952	0.2857	0.4524	0.8039	0.8852	0.9245	0.8543
GF	-0.3084	-0.0833	-0.2620	-0.1334	-0.5952	-0.2857	0.2143	0.9048

Continued Table 10

	Italy				Lithuania			
TSR_SME	-0.1516	-0.5107	-0.6485	-0.7924	-0.6235	-0.6529	0.1932	0.7474
TSR_LF	-0.1516	-0.5107	-0.6485	-0.7924	-0.6235	-0.6529	0.1932	0.7474
TI	0.6429	0.2857	-0.2143	-0.8095	-0.2384	0.0531	0.6439	0.6801
GF	-0.4630	-0.1016	0.6363	0.7642	-0.5598	-0.2629	0.2770	0.1534
	The Netherlands				Portugal			
TSR_SME	0.1147	0.3890	0.6042	0.5567	-0.8607	-0.7835	-0.0818	0.5361
TSR_LF	0.7873	0.7286	0.5391	0.2183	-0.8607	-0.7835	-0.0818	0.5361
TI	0.6079	0.8004	0.7780	0.4106	0.6599	0.5414	0.6690	0.6349
GF	-0.3571	-0.2143	0.2857	0.5714	0.0951	0.1360	0.5854	0.7933
	Slovenia				Spain			
TSR_SME	0.4980	0.2682	-0.0741	0.1730	-0.7835	-0.7326	-0.4124	-0.5774
TSR_LF	0.4980	0.2682	-0.0741	0.1730	-0.7835	-0.7326	-0.4124	-0.5774
TI	-0.1607	0.1787	0.2497	0.3099	0.3686	-0.0818	-0.3511	-0.3908
GF	-0.1190	-0.3571	-0.2619	-0.2619	-0.9754	-0.9588	-0.8406	-0.6925
	The United Kingdom							
TSR_SME	0.7979	0.6301	0.3004	0.4506				
TSR_LF	-0.6074	-0.8017	-0.5599	-0.2170				
TI	0.6190	0.5238	0.5238	0.5238				
GF	0.1764	0.6986	0.9397	0.6741				

Notes: TSR_SME – the hidden rate of tax subsidy on R&D costs for small and medium enterprises; TSR_LF – the hidden rate of tax subsidy on R&D costs for large businesses; TI – tax incentives for R&D (indirect government support); GF – direct government funding of the business sector's R&D expenditures.

Sources: developed by the authors.

Table 11. Identifying the strength and nature of the relationship between indicators of tax incentives for R&D and the share of investment in GDP (considering time lags for the period from 2007 to 2017)

Indicator	Time lag, years				Time lag, years			
	0	1	2	3	0	1	2	3
	Belgium				The Czech Republic			
TSR_SME	0.2267	0.4939	0.7806	0.6809	-0.4364	0.0000	0.0913	0.4342
TSR_LF	0.2267	0.4939	0.7806	0.6809	-0.4364	0.0000	0.0913	0.4342
TI	-0.3080	-0.1608	0.5516	0.5541	-0.8115	-0.7510	-0.7039	-0.5685
GF	-0.5870	-0.2366	0.2858	-0.1880	0.3238	0.3095	0.0768	0.0055
	Denmark				France			
TSR_SME	-	-	-	-	-0.5070	-0.8238	-0.4119	-0.1989
TSR_LF	-	-	-	-	-0.5070	-0.8238	-0.4119	-0.1989
TI	0.9762	0.9048	0.9102	0.9102	-0.5749	-0.2156	0.1317	-0.0479
GF	-0.3423	-0.3898	-0.3749	-0.4613	0.5384	0.0089	0.3346	0.5079
	Hungary				Ireland			
TSR_SME	0.6015	0.6138	0.3273	-0.4419	0.1706	0.4093	0.5360	0.5905
TSR_LF	0.3912	0.6508	0.4447	-0.4005	0.1706	0.4093	0.5360	0.5905
TI	-0.1429	-0.6429	-0.5476	-0.5238	0.0225	0.5808	0.8793	0.9177
GF	-0.2102	-0.3601	0.2302	0.3188	-0.6190	-0.2619	0.2381	0.8333
	Italy				Lithuania			
TSR_SME	0.5113	0.7299	0.9208	0.9089	-0.7443	-0.9335	0.2094	0.3657
TSR_LF	0.5113	0.7299	0.9208	0.9089	-0.7443	-0.9335	0.2094	0.3657
TI	0.0000	0.2857	0.5238	0.6190	-0.5376	-0.2508	0.6141	0.1466
GF	-0.0043	-0.3321	-0.8403	-0.7644	-0.4088	-0.1696	-0.0832	0.1221
	The Netherlands				Portugal			
TSR_SME	-0.3850	-0.5166	-0.4923	-0.3935	0.2217	0.0412	-0.5183	-0.8660
TSR_LF	-0.5653	-0.2677	0.1120	0.3248	0.2217	0.0412	-0.5183	-0.8660
TI	-0.7194	-0.4646	-0.2189	-0.0832	-0.5596	-0.5105	-0.5006	-0.6131
GF	0.2036	-0.3234	-0.4551	-0.6467	-0.5567	-0.5839	-0.6089	-0.4969

Continued Table 11

	Slovenia				Spain			
TSR_SME	-0.7151	-0.4597	-0.7042	-0.7660	0.0412	-0.0468	-0.2474	0.5774
TSR_LF	-0.7151	-0.4597	-0.7042	-0.7660	0.0412	-0.0468	-0.2474	0.5774
TI	-0.8131	-0.6699	-0.6840	-0.7362	-0.0010	0.2670	0.4908	0.4771
GF	0.7381	0.4048	-0.0952	-0.5238	0.8086	0.6709	0.6135	0.3510
	The United Kingdom							
TSR_SME	0.3805	0.8401	0.9011	0.8010				
TSR_LF	0.3589	-0.1607	-0.5983	-0.9117				
TI	0.8333	0.8571	0.8571	0.8571				
GF	-0.4961	0.0501	0.5311	0.6643				

Notes: TSR_SME – the hidden rate of tax subsidy on R&D costs for small and medium enterprises; TSR_LF – the hidden rate of tax subsidy on R&D costs for large businesses; TI - tax incentives for R&D (indirect government support); GF – direct government funding of the business sector's R&D expenditures.

Table 12. Identifying the strength and nature of the relationship between R&D tax incentives and the net international investment position (considering time lags for the period from 2007 to 2017)

Indicator	Time lag, years				Time lag, years			
	0	1	2	3	0	1	2	3
	Belgium				The Czech Republic			
TSR_SME	0.0563	0.3273	0.2478	0.1277	0.8729	0.4364	-0.0913	-0.5874
TSR_LF	0.0563	0.3273	0.2478	0.1277	0.8729	0.4364	-0.0913	-0.5874
TI	0.3879	0.1136	-0.1380	-0.0034	0.3370	0.6608	0.8889	0.9605
GF	0.1868	-0.0491	-0.6331	-0.5605	-0.9224	-0.8586	-0.5274	0.0360
	Denmark				France			
TSR_SME	-	-	-	-	-0.1901	-0.2852	-0.6654	-0.5779
TSR_LF	-	-	-	-	-0.1901	-0.2852	-0.6654	-0.5779
TI	0.7619	0.7381	0.7066	0.7545	-0.4192	-0.3353	-0.5150	-0.8982
GF	-0.3068	0.0122	0.2490	-0.2241	-0.0715	0.0608	0.5322	0.7477
	Hungary				Ireland			
TSR_SME	-0.0491	0.3314	0.4728	0.3069	-0.4619	-0.2358	-0.7217	-0.6990
TSR_LF	-0.0782	0.2003	0.5189	0.3504	-0.4619	-0.2358	-0.7217	-0.6990
TI	-0.1190	-0.4048	-0.3810	-0.0238	-0.5573	-0.5334	-0.6296	-0.5057
GF	0.0676	0.0635	0.1759	-0.3038	0.7143	0.2143	-0.4048	-0.9762
	Italy				Lithuania			
TSR_SME	0.1814	0.0128	-0.0173	-0.3572	0.0354	-0.0821	0.3885	0.4239
TSR_LF	0.1814	0.0128	-0.0173	-0.3572	0.0354	-0.0821	0.3885	0.4239
TI	0.5952	0.5238	0.3095	-0.2857	0.5308	0.6058	0.6864	0.3688
GF	-0.8054	-0.6406	0.1266	0.2897	-0.6005	-0.1842	0.0848	0.1078
	The Netherlands				Portugal			
TSR_SME	0.5578	0.4045	0.2281	0.3818	0.0522	-0.2062	-0.5455	-0.8660
TSR_LF	0.9657	0.9757	0.9767	0.9468	0.0522	-0.2062	-0.5455	-0.8660
TI	0.8912	0.8676	0.8441	0.8967	-0.3565	-0.1697	0.0665	-0.6200
GF	-0.7381	-0.8571	-0.7857	-0.2381	-0.8027	-0.7062	-0.2321	-0.0795
	Slovenia				Spain			
TSR_SME	0.3959	0.6385	0.7165	0.8895	-0.8348	-0.7572	-0.5009	-0.0835
TSR_LF	0.3959	0.6385	0.7165	0.8895	-0.8348	-0.7572	-0.5009	-0.0835
TI	0.3385	0.8247	0.8802	0.9746	0.2976	0.2858	0.2489	0.4774
GF	-0.8095	-0.6905	0.0238	0.5714	-0.1058	-0.4608	-0.5875	-0.7064
	The United Kingdom							
TSR_SME	-0.2332	0.2224	0.1502	0.1001				
TSR_LF	0.5886	0.4829	0.0031	-0.2660				
TI	0.1905	0.1429	0.1429	0.1429				
GF	-0.4986	-0.4687	0.0803	0.0275				

Notes: TSR_SME – the hidden rate of tax subsidy on R&D costs for small and medium enterprises; TSR_LF – the hidden rate of tax subsidy on R&D costs for large businesses; TI - tax incentives for R&D (indirect government support); GF – direct government funding of the business sector's R&D expenditures.

Sources: developed by the authors.

Table 13 shows the summary results of correlation analysis and identification of lags that provoked the maximum relationship between the indicators of tax incentives for R&D and IP of the country and other macroeconomic indicators.

Table 13. Results of correlation analysis of R&D tax incentives (lag, years/correlation coefficient)

	BERD				INV corp				INV				NIIP			
	R1	R2	TI	GF	R1	R2	TI	GF	R1	R2	TI	GF	R1	R2	TI	GF
BEL	3 / 0.8	3 / 0.8	2 / 0.8	0 / -0.9	2 / 0.9	2 / 0.9	2 / 0.9	0 / -0.5	2 / 0.8	2 / 0.8	2 / 0.6	0 / -0.6	1 / 0.3	1 / 0.3	0 / 0.4	2 / -0.6
CZE	2 / 0.9	2 / 0.9	0 / -0.8	3 / -0.7	3 / -0.5	3 / -0.5	1 / 0.8	0 / -0.4	0 / -0.4	0 / -0.4	0 / -0.8	0 / 0.3	0 / 0.9	0 / 0.9	3 / 0.96	0 / -0.9
DNK	–	–	0 / -0.8	0 / 0.6	–	–	0 / 0.9	2 / -0.4	–	–	0 / 0.98	3 / -0.5	–	–	0 / 0.8	0 / -0.3
FRA	3 / 0.9	3 / 0.9	2 / 0.9	0 / -0.7	3 / 0.96	3 / 0.96	3 / 0.9	3 / -0.6	1 / -0.8	1 / -0.8	0 / -0.6	0 / 0.5	2 / -0.7	2 / -0.7	3 / -0.9	3 / 0.7
HUN	1 / 0.8	2 / 0.8	2 / -0.6	3 / 0.9	3 / 0.6	3 / 0.5	3 / 0.5	0 / -0.3	0 / 0.6	1 / 0.7	1 / -0.7	1 / -0.4	2 / 0.5	2 / 0.5	1 / -0.4	3 / -0.3
IRL	2 / -0.3	2 / -0.3	2 / -0.4	3 / -0.6	0 / 0.9	0 / 0.9	1 / 0.9	0 / -0.6	3 / 0.6	3 / 0.6	2 / 0.9	0 / -0.6	2 / -0.7	2 / -0.7	2 / -0.6	3 / -0.98
ITA	3 / -0.7	3 / -0.7	0 / 0.6	0 / -0.7	3 / -0.8	3 / -0.8	3 / -0.8	3 / 0.8	2 / 0.9	2 / 0.9	3 / 0.6	2 / -0.8	3 / -0.4	3 / -0.4	0 / 0.6	0 / -0.8
LTU	3 / -0.3	3 / -0.3	1 / 0.6	0 / -0.5	3 / 0.8	3 / 0.8	3 / 0.7	1 / -0.6	1 / -0.9	1 / -0.9	2 / 0.6	0 / -0.4	2 / 0.4	2 / 0.4	2 / 0.7	0 / -0.6
NLD	2 / 0.7	0 / 0.7	1 / 0.8	0 / -0.4	2 / 0.6	0 / 0.8	1 / 0.8	3 / 0.6	1 / 0.5	0 / -0.6	0 / -0.7	3 / -0.6	0 / 0.6	1 / 0.98	0 / 0.9	1 / -0.9
PRT	1 / -0.4	1 / -0.4	2 / 0.4	1 / -0.9	1 / -0.9	1 / -0.9	0 / 0.7	3 / 0.8	3 / -0.9	3 / -0.9	0 / -0.6	0 / -0.6	3 / -0.9	3 / -0.9	3 / -0.6	0 / -0.8
SVN	3 / 0.9	3 / 0.9	0 / 0.8	0 / -0.8	0 / 0.5	0 / 0.5	3 / 0.3	1 / -0.4	3 / -0.8	3 / -0.8	0 / -0.8	0 / 0.7	3 / 0.9	3 / 0.9	3 / 0.97	0 / -0.8
ESP	1 / -0.8	1 / -0.8	0 / 0.5	1 / -0.9	1 / -0.8	1 / -0.8	0 / 0.4	0/ -0.98	3 / 0.6	3 / 0.6	2 / 0.5	0 / 0.8	0 / -0.8	0 / -0.8	3 / 0.5	3 / -0.7
UK	2 / 0.95	3 / -0.7	1 / 0.98	3 / 0.8	0 / 0.8	1 / -0.8	0 / 0.6	2 / 0.94	2 / 0.9	3 / -0.9	1 / 0.9	3 / 0.7	0 / -0.2	0 / 0.6	0 / 0.2	0 / -0.5

Notes: – - no connection; BERD – share of R&D expenditures financed by the business sector; INV corp – share of corporate sector investments; INV – share of investment in GDP; NIIP – net international investment position; R1, R2 – hidden tax subsidy rate on R&D expenditures for small and medium and large enterprises, respectively; TI – tax benefits for R&D; GF – direct state financing of business sector expenditures on R&D; BEL – Belgium, CZE – the Czech Republic, DNK – Denmark, FRA – France, HUN – Hungary, IRL – Ireland, ITA – Italy, LTU – Lithuania, NLD – the Netherlands, PRT– Portugal, SVN – Slovenia, ESP – Spain, UK – the United Kingdom.

The Granger test was used to examine the direction of the impact of tax incentives' studied indicators. According to the accepted hypothesis, they affect the indicators of R&D expenditures financed by the business sector, corporate sector investment, share of investment in GDP and net international investment position (Table 14).

Table 14. Characteristics of the direction of the impact of tax incentives based on the results of the Granger test

Indicator	TSR, TI and GF affect BERD	TSR, TI and GF affect INV corp	TSR, TI and GF affect INV	TSR, TI and GF affect NIIP
Belgium	TSR → BERD TI → BERD	TSR → INV corp TI → INV corp GF ←INV corp	TSR → INV TI → INV	TSR ←NIIP TI ←NIIP
The Czech Republic	TSR ↔ BERD GF ← BERD	TI ↔ INV corp GF ←INV corp	TSR → INV TI → INV GF → INV	TSR → NIIP TI → NIIP GF → NIIP

Continued Table 14

Denmark	–	TI → INV corp	TI ↔ INV	TI ←NIIP GF ←NIIP
France	TI → BERD	TI ← INV corp	TSR → INV TI ↔ INV	TI ←NIIP GF ←NIIP
Hungary	TI ← BERD	GF ←INV corp	GF → INV TSR ←INV	TSR → NIIP TI ←NIIP
Ireland	–	–	TI → INV GF → INV	TI → NIIP GF ←NIIP
Italy	–	TSR ← INV corp TI ← INV corp	TSR → INV TI ← INV GF ↔ INV	TSR → NIIP TI → NIIP
Lithuania	TI → BERD	TSR → INV corp TI → INV corp	TSR ↔ INV TI → INV	TSR → NIIP TI → NIIP GF → NIIP
The Netherlands	TSR → BERD TI → BERD GF ↔ BERD	TSR → INV corp TI → INV corp GF ←INV corp	–	TSR ↔ NIIP GF → NIIP
Portugal	GF ↔ BERD	GF ←INV corp	TSR → INV	TI ←NIIP
Slovenia	–	TSR → INV corp TI → INV corp	GF ←INV	TI → NIIP GF ↔ NIIP
Spain	TI ↔ BERD GF → BERD	TI → INV corp GF →INV corp	TSR ↔ INV TI ↔ INV GF ←INV	TI ← NIIP GF →NIIP
The United Kingdom	–	TI ← INV corp	TSR → INV TI ← INV	TSR → NIIP TI → NIIP GF → NIIP

Notes: BERD – the share of R&D expenditures financed by the business sector; INV corp – the share of corporate sector investments; INV – the share of investment in GDP; NIIP – net international investment position; TSR – the hidden rate of tax subsidy on R&D expenses; TI – tax incentives for R&D (indirect government support); GF is direct government funding of the business sector's R&D expenditures.

Sources: developed by the authors.

Considering the results of the Granger test and the level of statistical significance of the calculated Pearson/Spearman correlation coefficients with time lags from 0 to 3 years, there are the following empirically substantiated conclusions:

1) the impact of the hidden rate of tax subsidy on R&D expenditures on:

– the share of gross domestic expenditure on R&D financed by the business sector is highest in the Netherlands without a time lag for LF and with a lag of 2 years for SMEs; in the Czech Republic with a lag of 2 years; and Belgium with a lag of 3 years is direct);

– the share of investments made by the corporate sector is the highest in the Netherlands (for LF) without time lag; in Belgium with a lag of 2 years and in Lithuania with a lag of 3 years; medium – in Slovenia without a time lag; and the Netherlands (for SMEs) with a lag of 2 years (the nature of the impact is direct);

– the share of investment in GDP is the highest in France and Lithuania with a lag of 1 year; in Belgium, Italy and the United Kingdom (for SMEs) with a lag of 2 years; in Portugal and the United Kingdom (for LF) with lag at 3 years; medium – in Spain with a lag of 3 years (the nature of the impact is direct in 4 countries and reversed in 4 countries);

– a net international investment position is the highest in the Czech Republic without a time lag; in the Netherlands (for LF) with a lag of 1 year; medium – in the Netherlands (for SMEs) without time lag; in Great Britain (for LF) with lag in 1 year and Hungary with lag in 2 years (the nature of influence is direct);

2) the impact of tax benefits on R&D (indirect government support) on:

‒ the share of gross domestic expenditure on R&D financed by the business sector is the highest in the Netherlands with a lag of 1 year; in Belgium and France with a lag of 2 years; medium – in Spain without time lag; and in Lithuania with lag in 1 year (the nature of the impact is direct);

‒ the share of investments made by the corporate sector is the highest in Denmark without time lag; in the Czech Republic and the Netherlands with a lag of 1 year; in Belgium with a lag of 2 years; in Lithuania with a lag of 3 years (the impact is direct);

‒ the share of investment in GDP is the highest in the Czech Republic and Denmark without a time lag; in Ireland with a lag of 2 years; medium – in France without time lag; in Belgium, Spain and Lithuania with lag in 2 years (the nature of the impact is direct in 5 countries and reversed in 2 countries);

‒ a net international investment position is significant in Lithuania with a lag of 2 years; in the Czech Republic and Slovenia with a lag of 3 years; medium – in Italy without a time lag and Ireland with a lag of 2 years (the impact is direct at four countries and vice versa in 1 country);

3) the impact of direct public funding of business sector expenditures on R&D on:

‒ the share of gross domestic expenditure on R&D financed by the business sector is as high as possible in Portugal and Spain with a lag of 1 year (the nature of the impact is reversed);

‒ the share of investments made by the corporate sector is the highest in Spain without time lag (the nature of the impact is reversed);

‒ the share of investment in GDP is the highest in Italy with a lag of 2 years; medium – in Ireland without a time lag (the nature of the impact is reversed);

‒ the net international investment position is the highest in the Czech Republic and Slovenia without time lag; in the Netherlands with a time lag of 1 year; in Spain with a time lag of 3 years; the average – in Lithuania and the UK without time lag (nature of the impact is inverted).

A linear regression model for the time series was built to assess the impact of R&D tax incentives on the share of gross domestic R&D expenditures financed by the business sector; the share of investments made by the corporate sector; the share of investment in GDP; the indicator of the international investment position on the example of countries where the significant influence of the vast majority of tax incentives on the studied indicators is empirically confirmed.

The following are considered as control factor variables:

- labour force indicator (% of the total population aged 15-64) (Table 15);

Table 15. The share of labor resources (% of the total population aged 15-64)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BEL	67,21	67,20	66,94	67,65	66,62	66,79	67,44	67,72	67,68	67,73	68,06
CZE	69,92	69,69	70,04	70,12	70,45	71,48	72,80	73,53	74,13	75,19	76,11
DNK	80,23	80,80	80,28	79,32	79,04	78,35	77,89	77,94	78,38	79,94	78,84
FRA	69,66	69,79	70,13	70,17	70,04	70,58	71,01	70,93	71,18	71,38	71,54
HUN	61,52	61,14	61,16	61,82	62,29	63,49	64,33	66,60	68,37	69,95	71,09
IRL	75,25	74,60	72,93	71,63	71,23	71,24	71,97	72,08	72,28	72,85	72,91
ITA	62,37	62,84	62,19	62,02	62,15	63,57	63,38	63,95	64,07	64,98	65,49
LTU	67,93	68,43	69,63	70,33	71,51	71,99	72,55	73,75	74,09	75,55	76,10
NLD	76,77	77,85	78,10	77,90	78,05	78,90	79,28	79,00	79,66	79,73	79,79
PRT	73,97	74,03	73,43	73,56	73,55	73,38	73,05	73,30	73,60	73,97	74,91
SVN	71,41	71,85	71,70	71,76	70,77	70,89	70,79	70,99	71,64	71,54	74,24
ESP	71,77	72,75	73,16	73,63	73,95	74,29	74,29	74,22	74,38	74,38	74,16
UK	75,40	75,68	75,49	75,25	75,35	75,87	76,25	76,55	76,79	77,16	77,42

Notes: BEL – Belgium, CZE – The Czech Republic, DNK – Denmark, FRA – France, HUN – Hungary, IRL – Ireland, ITA – Italy, LTU – Lithuania, NLD – The Netherlands, PRT – Portugal, SVN – Slovenia, ESP – Spain, UK –Great Britain.

Sources: developed by the authors based on (World Bank data, Labor force participation rate, 2007-2017).

- inflation rate (GDP deflator, %) (Table 16).

Table 16. Inflation, GDP deflator, %

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BEL	1,93	1,91	0,53	1,89	1,81	1,96	1,27	0,98	1,34	1,74	1,72
CZE	3,52	2,05	2,60	-1,43	0,02	1,46	1,43	2,48	1,17	1,27	1,44
DNK	2,43	4,13	0,53	3,22	0,64	2,38	0,89	1,03	0,43	0,25	1,13
FRA	2,56	2,37	0,07	1,07	0,95	1,16	0,78	0,58	1,14	0,52	0,46
HUN	5,44	4,79	4,19	2,38	2,18	3,20	2,98	3,59	2,46	0,97	3,70
IRL	1,21	-0,32	-4,56	-3,15	1,50	2,28	1,23	-0,11	7,79	-0,30	1,13
ITA	2,48	2,40	1,68	0,44	1,61	1,55	1,15	0,91	0,93	1,14	0,69
LTU	8,57	9,70	-3,30	2,27	5,38	2,78	1,35	0,92	0,09	1,61	4,25
NLD	2,07	2,31	0,22	0,94	0,19	1,45	1,28	0,25	0,77	0,45	1,26
PRT	2,97	1,74	1,10	0,64	-0,27	-0,39	2,25	0,70	2,02	1,72	1,51
SVN	4,18	4,47	3,40	-1,03	1,04	0,48	1,60	0,46	1,01	0,75	1,58
ESP	3,42	2,25	0,14	0,15	-0,02	-0,11	0,40	-0,22	0,55	0,32	1,38
UK	2,58	2,88	1,65	1,53	2,04	1,66	1,90	1,83	0,58	2,14	1,89

Notes: BEL – Belgium, CZE – The Czech Republic, DNK – Denmark, FRA – France, HUN – Hungary, IRL – Ireland, ITA – Italy, LTU – Lithuania, NLD – The Netherlands, PRT – Portugal, SVN – Slovenia, ESP – Spain, UK –Great Britain.

Sources: developed by the authors based on (World Bank data, Inflation, GDP deflator, 2007-2017).

- the interest rate on long-term liabilities (Maastricht criterion interest rates) (Table 17)

Table 17. Maastricht criterion interest rates, %

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BEL	4,33	4,42	3,90	3,46	4,23	3,00	2,41	1,71	0,84	0,48	0,72
CZE	4,30	4,63	4,84	3,88	3,71	2,78	2,11	1,58	0,58	0,43	0,98
DNK	4,29	4,28	3,59	2,93	2,73	1,40	1,75	1,32	0,69	0,32	0,48
FRA	4,30	4,23	3,65	3,12	3,32	2,54	2,20	1,67	0,84	0,47	0,81
HUN	6,74	8,24	9,12	7,28	7,63	7,89	5,92	4,81	3,43	3,14	2,96
IRL	4,31	4,53	5,23	5,74	9,60	6,17	3,79	2,37	1,18	0,74	0,80
ITA	4,49	4,68	4,31	4,04	5,42	5,49	4,32	2,89	1,71	1,49	2,11
LTU	4,54	5,61	14,00	5,57	5,16	4,83	3,83	2,79	1,38	0,90	0,31
NLD	4,29	4,23	3,69	2,99	2,99	1,93	1,96	1,45	0,69	0,29	0,52
PRT	4,42	4,52	4,21	5,40	10,24	10,55	6,29	3,75	2,42	3,17	3,05
SVN	4,53	4,61	4,38	3,83	4,97	5,81	5,81	3,27	1,71	1,15	0,96
ESP	4,31	4,37	3,98	4,25	5,44	5,85	4,56	2,72	1,73	1,39	1,56
UK	5,06	4,50	3,36	3,36	2,87	1,74	2,03	2,14	1,79	1,22	1,18

Notes: BEL – Belgium, CZE – The Czech Republic, DNK – Denmark, FRA – France, HUN – Hungary, IRL – Ireland, ITA – Italy, LTU – Lithuania, NLD – The Netherlands, PRT – Portugal, SVN – Slovenia, ESP – Spain, UK –Great Britain.

Sources: developed by the authors based on (EU Statistical Office data, Maastricht criterion interest rates, 2007-2017).

Table 18 shows the results of modelling the impact of R&D tax incentives on the share of gross domestic R&D expenditures financed by the business sector on Belgium's example. Notably, modelling provides the generating natural logarithms of variables, given that most indicators of R&D tax incentives showing the results of the Shapiro-Wilk test (Table 18).

Table 18. The results of building a linear regression model to assess the impact of R&D tax incentives on the share of gross domestic R&D expenditure financed by the business sector (on the example of Belgium)

lnBERD	Coef.	Robust Std. Err.	t	P >|t|	[95% Conf. Interval]	
lnTSR	.2447539	.0510345	4.80	0.009	.1030593	.3864485
lnGF	-.2618628	.0292623	-8.95	0.001	-.3431079	-.1806177

Continued Table 18

L.lnL	1.26965	.5267353	2.41	0.074*	-.1928018	2.732101
L.lnIR	.0322829	.0078011	4.14	0.014	.0106236	.0539422
lnI	.0319198	.0042003	7.60	0.002	.0202578	.0435817
_cons	-1.471753	2.173924	-0.68	0.536*	-7.507533	4.564026
		Prob > F = 0.0002, R-squared = 0.9755				
L.lnTI	.0235808	.0083306	2.83	0.047	.0004513	.0467103
lnGF	-.2444922	.0335459	-7.29	0.002	-.3376304	-.151354
L.lnL	.7908687	.6812537	1.16	0.310*	-1.100595	2.682332
L.lnIR	.0265938	.0106522	2.50	0.067*	-.0029815	.0561691
lnI	.0154909	.0045189	3.43	0.027	.0029444	.0280374
_cons	.178242	2.875912	0.06	0.954*	-7.806569	8.163053
		Prob > F = 0.0007, R-squared = 0.9638				

Notes: * – the value of the coefficient is not statistically significant (P> |t|) > 0.05); BERD – the share of R&D expenditures financed by the business sector; TSR – the hidden rate of tax subsidy on R&D expenses; TI – tax benefits for R&D; GF – direct state financing of business sector expenditures on R&D; I – inflation rate; IR – the interest rate on long-term liabilities; L – an indicator of labour resources.

Sources: developed by the authors.

The obtained values of Prob> F = 0.0002, R-squared = 0.9755 and Prob> F = 0.0007, R-squared = 0.9638 indicate the adequacy of the constructed models, respectively. Coefficients describing the impact of R&D tax incentives (lnTSR, lnGF, lnTI) are statistically significant (P> | t |) <0.05). The regression of the effect of the hidden rate of the tax subsidy on R&D expenditures and direct public funding of business sector R&D expenditures on the amount of gross domestic R&D expenditures financed by businesses, for example in Belgium, is as follows:

$$lnBERD_{BEL} = 0.24lnTSR - 0.26lnGF + 1.27lnL_{t-1} + 0.03lnIR_{t-1} + 0.03lnI - 1.47 \tag{1}$$

With an increase in the hidden tax subsidy rate on R&D expenditures by 1%, the value of gross domestic R&D expenditures financed by businesses would increase by an average of 0.24%. On the other hand, if the volume of direct state financing of business sector expenditures on R&D rises by 1%, the value of gross domestic spending on R&D financed by businesses would decrease by 0.26% on average. The regression of the effect of the tax incentives impact on R&D and direct public financing of business sector expenditures on R&D on the amount of gross domestic expenditure of R&D financed by business, on the example of Belgium, is as follows:

$$lnBERD_{BEL} = 0.02lnTI_{t-1} - 0.24lnGF + 0.79lnL_{t-1} + 0.03lnIR_{t-1} + 0.02lnI + 0.18 \tag{2}$$

With the growth of R&D tax benefits by 1%, the gross domestic R&D expenditures financed by businesses would increase by an average of 0.02% with a time lag of 1 year. Instead, with an increase in direct government funding for business sector R&D expenditures by 1%, the gross domestic R&D expenditures financed by businesses would decrease by an average of 0.24% (excluding time lag). Table 19 shows the results of modelling the impact of R&D tax incentives on the gross domestic R&D expenditures share financed by the business sector (on the Czech Republic example).

Table 19. The results of building a linear regression model to assess the impact of R&D tax incentives on the share of R&D gross domestic expenditure financed by the business sector (on the example of the Czech Republic)

lnBERD	Coef.	Robust Std. Err.	t	P >|t|	[95% Conf. Interval]	
L.lnTSR	1.973325	.0993985	19.85	0.032	.7103473	3.236302
L2.lnGF	-.2965119	.0083393	-35.56	0.018	-.4024727	-.1905511

Continued Table 19

L1.lnL	-7.613918	.1407899	-54.08	0.012	-9.402824	-5.825013
L1.lnIR	-.1742106	.004052	-42.99	0.015	-.2256959	-.1227254
L3.lnI	-.0346468	.001264	-27.41	0.023	-.0507079	-.0185857
_cons	38.77677	.6792833	57.08	0.011	30.14565	47.40788
	Prob > F = 0.0092 , R-squared = 0.9994					
lnTI	-.3447596	.003299	-104.50	0.000	-.3589543	-.330565
L1.lnL	-2.93603	.0652091	-45.02	0.000	-3.216602	-2.655458
L1.lnIR	-.1266926	.0016062	-78.88	0.000	-.1336036	-.1197815
L3.lnI	-.0073465	.0001206	-60.91	0.000	-.0078654	-.0068275
_cons	15.22055	.2883256	52.79	0.000	13.97999	16.46112
	Prob > F = 0.0000, R-squared = 0.9999					

Notes: BERD – the share of R&D expenditures financed by the business sector; TSR - the hidden rate of tax subsidy on R&D expenses; TI – tax benefits for R&D; GF – direct state financing of business sector expenditures on R&D; I – inflation rate; IR – the interest rate on long-term liabilities; L – an indicator of labour resources.

Sources: developed by the authors.

The obtained values of Prob> F = 0.0092, R-squared = 0.9994 and Prob> F = 0.0000, R-squared = 0.9999 indicate the adequacy of the constructed models, respectively. Coefficients describing the impact of R&D tax incentives (lnTSR, lnGF, lnTI) are statistically significant (P> | t |) <0.05). The regression of the effect of the hidden rate of tax subsidy on R&D expenditures and direct state financing of business sector R&D expenditures on the amount of gross domestic R&D expenditures financed by businesses, as exemplified by the Czech Republic, is as follows:

$$lnBERD_{CZE} = 1.97lnTSR_{t-1} - 0.3lnGF_{t-2} - 7.61lnL_{t-1} - 0.17lnIR_{t-1} - 0.03lnI_{t-3} + 38.78 \qquad (3)$$

With an increase in the hidden tax subsidy rate on R&D expenditures by 1%, the value of gross domestic R&D expenditures financed by businesses would increase by an average of 1.97% with a time lag of 1 year. Instead, suppose the amount of direct state funding of business sector R&D expenditures increases by 1%. In that case, the gross domestic R&D expenditures financed by businesses would decrease by an average of 0.3% with a time lag of 2 years. The regression equation of the impact of tax incentives on R&D on the amount of R&D gross domestic expenditure financed by business (on the Czech Republic example) is as follows:

$$lnBERD_{CZE} = -0.34lnTI - 2.93lnL_{t-1} - 0.13lnIR_{t-1} - 0.01lnI_{t-3} + 15.22 \qquad (4)$$

With an increase in R&D tax benefits by 1%, the gross domestic R&D expenditures financed by businesses would decrease by an average of 0.34% (excluding time lag).

Table 20 shows the results of modelling the impact of R&D tax incentives on the corporate sector's share of investments (on Belgium's example).

Table 20. The results of building a linear regression model to assess the impact of R&D tax incentives on the share of investment in the corporate sector (on the example of Belgium)

lnINV$_{corp}$	Coef.	Robust Std. Err.	t	P >|t|	[95% Conf. Interval]	
L3.lnTSR	.055544	.0045841	12.12	0.001	.0409555	.0701326
L.lnL	-.1921587	.2751888	-0.70	0.535*	-1.067932	.683615
L3.lnIR	-.030381	.0045504	-6.68	0.007	-.0448623	-.0158996
L2.lnI	-.0154491	.0027643	-5.59	0.011	-.0242462	-.006652
_cons	5.129405	1.160548	4.42	0.022	1.436022	8.822787
	Prob > F =0.0001, R-squared = 0.9897					
L2.lnTI	.0375217	.0018174	20.65	0.002	.0297019	.0453415
lnGF	.0373219	.0028969	12.88	0.006	.0248577	.049786

Continued Table 20

L.lnL	-.8697899	.1702914	-5.11	0.036	-1.602495	-.1370851
L3.lnIR	-.0301167	.0010357	-29.08	0.001	-.0345729	-.0256605
L2.lnI	-.0182766	.0007036	-25.97	0.001	-.0213041	-.0152491
_cons	8.027993	.7246892	11.08	0.008	4.909907	11.14608
Prob > F = 0.0001, R-squared = 0.9986						

Notes: * the value of the coefficient is not statistically significant (P> | t |)> 0.05); INVcorp – the share of corporate sector investments; TSR – the hidden rate of tax subsidy on R&D expenses; TI – tax benefits for R&D; GF – direct state financing of business sector expenditures on R&D; I – inflation rate; IR – the interest rate on long-term liabilities; L – an indicator of labour resources.

Sources: developed by the authors.

The obtained values of Prob> F = 0.0001, R-squared = 0.9897 and Prob> F = 0.0001, R-squared = 0.9986 indicate the adequacy of the constructed models, respectively. Coefficients describing the impact of R&D tax incentives (lnTSR, lnGF, lnTI) are statistically significant (P> | t |) <0.05).

The regression equation of the tax subsidy hidden rate impact on R&D expenditures by the corporate sector's investments share (on Belgium's example), is as follows:

$$\ln INV_{corp\ BEL} = 0.06\ln TSR_{t-3} - 0.19\ln L_{t-1} - 0.03\ln IR_{t-3} - 0.02\ln I_{t-2} + 5.13 \qquad (5)$$

With an increase in the hidden tax subsidy rate on R&D expenditures by 1%, the corporate sector's investment share would increase by an average of 0.06% with a time lag of 3 years.

The regression of the impact of tax benefits on R&D and direct public funding of the business sector's R&D expenditures by the share of investments made by the corporate sector (on the example of Belgium) is as follows:

$$\ln INV_{corp\ BEL} = 0.04\ln TI_{t-2} + 0.04\ln GF - 0.87\ln L_{t-1} - 0.03\ln IR_{t-3} - 0.02\ln I_{t-2} + 8.03 \qquad (6)$$

With a 1% increase in R&D tax benefits, the corporate sector's share of investments would increase by an average of 0.04% with a time lag of 2 years. Accordingly, if the volume of direct state financing of business sector expenditures on R&D increases by 1%, the value of gross domestic spending on R&D financed by the business would increase by an average of 0.04% (excluding time lag).

Table 21 shows the results of modelling the impact of R&D tax incentives on the share of the corporate sector's investments (on the Netherlands example).

Table 21. The results of building a linear regression model to assess the impact of R&D tax incentives on the share of investment in the corporate sector, on the example of the Netherlands (for large businesses)

INV corp	Coef.	Robust Std. Err.	t	P >|t|	[95% Conf. Interval]	
L.lnTI	.4036046	.1303528	3.10	0.053	-.0112363	.8184455
lnL	6.566013	1.491651	4.40	0.022	1.818915	11.31311
L.lnIR	.0801977	.0143874	5.57	0.011	.0344107	.1259848
L3.lnI	.0320156	.0063243	5.06	0.015	.0118887	.0521425
_cons	-23.90539	6.676841	-3.58	0.037	-45.15408	-2.656699
Prob > F = 0.0161, R-squared = 0.9353						

Notes: INV corp – the share of corporate sector investments; TI – tax benefits for R&D; I– inflation rate; IR – the interest rate on long-term liabilities; L – an indicator of labour resources.

Sources: developed by the authors.

The obtained values of Prob> F = 0.0161, R-squared = 0.9353 indicate the adequacy of the constructed model. The coefficient describing the impact of the R&D tax incentives indicator, in particular

lnTI, is statistically significant (P> | t |) <0.05).

The regression equation of the impact of tax incentives on R&D on the share of investments made by the corporate sector (on the Netherlands example), is as follows:

$$\ln INV_{corp\ NLD} = 0.4\ln TI_{t-1} + 6.57\ln L + 0.08\ln IR_{t-1} + 0.03\ln I_{t-3} - 23.9 \tag{7}$$

With a 1% increase in R&D tax benefits, the corporate sector's share of investments would increase by an average of 0.4% with a time lag of 1 year.

Table 22 shows the results of modelling the impact of R&D tax incentives on the share of investment in GDP on Belgium's example. The obtained values of Prob> F = 0.0050, R-squared = 0.8852 indicate the adequacy of the constructed models. The coefficient describing the effect of lnTI is statistically significant (P> | t |) <0.05).

The regression equation of the impact of tax incentives on R&D investment share in GDP (on the example of Belgium) is as follows:

$$INV_{BEL} = 0.04\ln TI_{t-2} + 2.63\ln L_{t-1} + 0.02\ln IR_{t-1} + 0.06\ln - 7.91 \tag{8}$$

With the growth of tax benefits on R&D by 1%, the share of GDP investment would increase by an average of 0.04% with a time lag of 2 years.

Table 22. The results of building a linear regression model to assess the impact of R&D tax incentives on the share of investment in GDP (on Belgium's example)

INV	Coef.	Robust Std. Err.	t	P >|t|	[95% Conf. Interval]	
L2.lnTI	.0374955	.007424	5.05	0.015	.0138691	.0611219
L.lnL	2.630118	.7482904	3.51	0.039	.248724	5.011512
L.lnIR	.0217146	.0061964	3.50	0.039	.0019948	.0414345
lnI	.0558579	.024094	2.32	0.103*	-.0208198	.1325357
_cons	-7.913952	3.154309	-2.51	0.087*	-17.95237	2.124466
		Prob > F = 0.0050, R-squared = 0.8852				

Notes: * – the value of the coefficient is not statistically significant (P> | t |)> 0.05); INV – the share of investment in GDP; TI – tax benefits for R&D; I – inflation rate; IR – the interest rate on long-term liabilities; L – an indicator of labour resources.

Sources: developed by the authors.

Table 23 shows the results of modelling the impact of R&D tax incentives on the share of investment in GDP on the example of Denmark.

Table 23. The results of building a linear regression model to assess the impact of R&D tax incentives on the share of investment in GDP (on Denmark's example)

INV	Coef.	Robust Std. Err.	t	P >|t|	[95% Conf. Interval]	
L3.lnTI	.0357366	.0058167	6.14	0.009	.0172253	.0542479
L3.lnGF	-.2938706	.0495498	-5.93	0.010	-.4515602	-.136181
lnL	-5.709226	.8728945	-6.54	0.007	-8.487166	-2.931286
lnIR	-.0281018	.0068519	-4.10	0.026	-.0499076	-.0062959
_cons	27.18846	3.669012	7.41	0.005	15.51203	38.8649
		Prob > F = 0.0030 , R-squared = 0.9968				

Notes: * – the value of the coefficient is not statistically significant (P> | t |)> 0.05); INV – the share of investment in GDP; TI – tax benefits for R&D; GF – direct state financing of business sector expenditures on R&D; IR – the interest rate on long-term liabilities; L – an indicator of labour resources.

Sources: developed by the authors.

The obtained values of Prob> F = 0.0030, R-squared = 0.9968 indicate the adequacy of the

constructed model. The coefficients describing the impact of R&D tax incentives (lnGF, lnTI) are statistically significant (P> | t |) <0.05).

The regression equation of the impact of tax benefits on R&D and direct public funding of business sector expenditures on R&D investment share in GDP (on the example of Denmark) is as follows:

$$INV_{DNK} = 0.04lnTI_{t-3} - 0.29lnGF_{t-3} - 5.71lnL - 0.03lnIR + 27.19 \qquad (9)$$

With the growth of tax benefits on R&D by 1%, the share of GDP investment would increase by an average of 0.04% with a time lag of 3 years. On the other hand, with an immediate increase in the volume of direct state financing of business sector expenditures on R&D by 1%, the share of GDP investments would decrease by an average of 0.29% with a time lag of 3 years.

Table 24 shows the results of modelling the impact of R&D tax incentives on the indicator of the international investment position on the Netherlands' example (for large enterprises).

The obtained values of Prob> F = 0.0001, R-squared = 0.9948 indicate the adequacy of the constructed model. The coefficients describing the influence of indicators are statistically significant (P> | t |) <0.05).

Table 24. The results of building a linear regression model to assess the impact of R&D tax incentives on the international investment position on the example of the Netherlands (for large businesses)

NIIP	Coef.	Robust Std. Err.	t	P >|t|	[95% Conf. Interval]	
L2.lnTSR	2.262221	.1075676	21.03	0.000	1.919893	2.604549
lnL	19.50311	4.889334	3.99	0.028	3.943072	35.06315
L3.lnIR	.6451611	.0635573	10.15	0.002	.4428935	.8474287
L3.lnI	-.0839681	.0135131	-6.21	0.008	-.1269727	-.0409635
_cons	-77.40223	21.60525	-3.58	0.037	-146.1598	-8.644676
Prob > F = 0.0000, R-squared = 0.9986						

Notes: NIIP – an indicator of the international investment position; TSR – the hidden rate of tax subsidy on R&D expenses; TI – tax benefits for R&D; IR – the interest rate on long-term liabilities; L – the indicator of labour resources.

Sources: developed by the authors.

The regression equation for the effect of the hidden tax subsidy rate on R&D expenditures in the international investment position (on the example of the Netherlands) is as follows:

$$NIIP_{NLD} = 2.26lnTSR_{t-2} + 19.5lnL + 0.65lnIR_{t-3} - 0.08lnI_{t-3} - 77.4 \qquad (10)$$

If the value of the hidden tax subsidy rate on R&D expenditures increases by 1%, the international investment position will increase by 2.26% with a time lag of 2 years.

Conclusions. This study based on the application of correlation analysis using the Pearson, Spearman, Shapiro-Wilk and Granger tests. In turn, the Granger test empirically confirmed the impact of high and medium significance of the tax subsidy hidden rate on R&D expenditures in the gross domestic spending share. R&D financed by the business sector on the percentage of investments made by the corporate sector on the net international investment position – direct with a time lag of 0-3 years, on the share of investment in GDP – direct in 4 countries and reversed in 4 countries with a lag of 2-3 years; tax benefits for R&D (indirect government support) – in most countries direct with a lag of 0-3 years; direct state financing of business sector expenditures on R&D – reversed with a lag of 0-2 years.

The obtained results empirically confirmed the influence of the tax stimulation for innovations on macroeconomic stability indicators. For formalizing the identified causal relationships, the study provides the lag models for those countries where they were most important (Belgium, Denmark, the Netherlands,

and the Czech Republic).

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Податкове стимулювання інновацій в контексті макроекономічної стабільності: аналіз причинно-наслідкових зв'язків

У статті розглянуто актуальну проблему податкового стимулювання інновацій, науково-дослідних і дослідно-конструкторських робіт, а також його вплив на рівень інноваційного розвитку та макроекономічну стабільність. Дослідження базується на аналізі причинно-наслідкових зв'язків, оцінці сили часових лагів та напрямків взаємного впливу податкових стимулів науково-дослідних і дослідно-конструкторських робіт та макропоказників. Систематизація літературних джерел та підходів до вирішення означеної проблематики вказує на те, що податкові стимули науково-дослідних і дослідно-конструкторських робіт вивчаються фрагментарно в контексті макроекономічної стабільності. Основною метою дослідження є вдосконалення методологічних основ обґрунтування вибору відповідних інструментів стимулювання інновацій з урахуванням причинно-наслідкових зв'язків податкових стимулів науково-дослідних і дослідно-конструкторських робіт та макропоказників. У статті представлені результати динамічного аналізу податкових пільг на науково-дослідні та дослідно-конструкторські роботи. Емпіричне дослідження проведено на основі панельних даних, сформованих для вибірки з 13 європейських країн за 2007-2017 роки. За отриманими результатами визначено значущість, силу та характер взаємозв'язку між досліджуваними показниками та наступними макропоказниками: рівень інноваційного розвитку країни, частка інвестицій у валовому внутрішньому продукті (загалом та в корпоративному секторі, зокрема), чиста міжнародна інвестиційна позиція, частка бізнес-сектору в структурі витрат на науково-дослідні та дослідно-конструкторські роботи. Коефіцієнти кореляції Пірсона та Спірмена було розраховувано залежно від підпорядкування змінних закону нормального розподілу (перевіреного тестом Шапіро-Вілка) на допустимому інтервалі обчислення з урахуванням часових лагів від 0 до 3 років. Причинність досліджуваних показників встановлена за допомогою тесту Грейнджера. Ці розрахунки важливі для розстановки пріоритетів у використанні інструментів

реалізації інноваційної підтримки. Автори надали найвищий пріоритет встановленню податкових стимулів науково-дослідних і дослідно-конструкторських робіт, оскільки вплив цього інструменту на всі вивчені макропоказники в більшості країн був прямим, і його ефект мав місце в найкоротші терміни (з часовим лагом 0–3 роки). Другий пріоритет надано встановленню прихованих ставок субсидій на оподаткування науково-дослідних і дослідно-конструкторських робіт бізнесу, оскільки вплив цього показника на більшість досліджуваних показників був статистично значущим та прямим із часовим лагом 0–3 роки. У статті обґрунтовано неефективність прямої державної фінансової підтримки інновацій, оскільки вплив цього показника на більшість аналізованих макропоказників був зворотним із часовим лагом 0–2 роки. Таким чином, державі доцільніше допомагати підприємцям шляхом надання податкових пільг для забезпечення інноваційного розвитку та макростабільності загалом, ніж шляхом прямого відшкодування витрат. У статті представлено побудовані лагові регресійні моделі для тих країн, де встановлені причинно-наслідкові зв'язки виявилися найбільш статистично значущими (Бельгія, Данія, Нідерланди та Чехія). Вони враховують темпи інфляції та процентні ставки за довгостроковими зобов'язаннями, а також кількість трудових ресурсів у країні як контрольні змінні.

Ключові слова: інвестиційна позиція, інновації, макроекономічна стабільність, макропоказники, НДДКР, податкові витрати на НДДКР, податкові стимули, податкові субсидії, причинно-наслідкові зв'язки, тест Грейнджера.