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INCOMPATIBILITY OF PUBLIC DEBT AND INNOVATION AS A PARADIGM OF MODERNITY

The relevance of the study is driven by the importance of public debt as an indicator of a country's financial stability and its significant impact on economic development. Meanwhile accumulation of state debt gradually lost the obviousness of the negative in the assessment of the economic health of states. The aim of the article is to analyze one of the arguments for such a determination, namely, that in conditions of dynamic economic growth, public debt can act as a factor in promoting innovative development. The methodological basis of the study is the application of the cluster analysis and curve testing in the framework of regression analysis. The research findings demonstrate no such relationship was found. At the same time, the existence of a short-term positive effect of the use of public debt for economic added value is shown. The prospects for further research lie in examining the methods of effective public debt management to guarantee economic recovery in combination with innovative development in Ukraine.

Key words: public debt, innovations, research & development, clusterization, economic value added.

JEL classification: H25, H63, M21, O320, P5

НЕСУМІСНІСТЬ ДЕРЖАВНОГО БОРГУ ТА ІННОВАЦІЙ ЯК ПАРАДИГМА СУЧАСНОСТІ

Актуальність дослідження зумовлена важливістю державного боргу як показника фінансової стабільності країни та його значним впливом на економічний розвиток. Водночас накопичення державного боргу поступово втрачало очевидність негативу в оцінці економічного здоров'я держав, особливо в сучасних умовах зростання показників державного боргу у різних країнах світу. Метою статті є аналіз одного з аргументів для такого визначення, а саме того, що в умовах динамічного економічного зростання державний борг може виступати чинником стимулювання інноваційного розвитку. Методологічною основою дослідження є застосування порівняльного аналізу економічних показників зарубіжних країн (ВВП, інвестиції в різні галузі економіки в дослідження і розробки) за даними Світового банку, кластерного аналізу та тестування кривої в рамках регресійного аналізу на основі пакету SPSS. У дослідженні були використані відповідні бібліотеки R. Сформовано гіпотезу дослідження, суть якої відобразити, що не існує статистично значущого зв'язку між державними чи приватними інвестиціями в інновації та державним боргом. Єдиним короткостроковим позитивним ефектом боргу може бути короткострокове накопичення економічної доданої вартості. Результати дослідження показують, що такого зв'язку не виявлено. Водночас показано наявність короткострокового позитивного ефекту від використання державного боргу для отримання економічної доданої вартості. Отже, зростання величини державного боргу не сприяє ні державним інвестиціям в інновації, ні (непрямо) інвестиціям бізнесу в дослідження та розробки. Політика, орієнтована на збільшення державного боргу, може мати лише тимчасові переваги, але перетворення його в довгостроковий інструмент пригнічує здатність економіки до розвитку та нововведень. Тому лише збалансована державна боргова політика є гарантією інноваційного розвитку країни. Відповідно до наведених результатів перспективи подальших досліджень полягають у вивченні методів ефективного управління державним боргом для забезпечення повосного економічного відновлення та зростання в поєднанні з інноваційним розвитком України.

Ключові слова: державний борг, управління державним боргом, інновації, дослідження та розробки, кластеризація, економічна додана вартість.

Statement of the problem. Accumulation of public debt has not been considered an overly critical phenomenon for developed countries for a long time. It is logical to assume that in conditions of positive GDP dynamics, as in the case of business, lending is an acceptable tool. However, if in the case of a business it is normal to receive a loan for technical re-equipment, promotion of innovation, entry into new markets, it is possible to assume that such a violation is permissible for governments. However, the question remains: can such loans be effective at the government level? On the other hand, is the use of such a tool acceptable for a long time?

There is a debate about the type of innovation that the large and small companies can implement. In particular, the implementation of disruptive or even radical innovations for big business is a problematic phenomenon, as it entails critical changes in technical equipment and social packages for employees. If we consider the state a mega-corporation, then it will be even more difficult for it to do so under the pressure of political parties, or rather the upcoming elections. And here the problem lies not even in understanding the need for society's transition to new technologies, but in the long-term nature of such solutions. The behaviour of political projects is usually cyclical and focused on the commonly understood interests of their own voters.

So, the hypothesis of our research: there is no statistically significant relationship between public or private investment in innovation and public debt. The only short-term positive effect of debt can be short-term accumulation of economic added value.

Analysis of recent research and publications. To analyze the impact of public debt on investment and innovation activity, the works of foreign authors who concentrated their research on individual countries or groups of countries were processed.

M.M. Croce [1], T.T. Nguyen, S. Raymond, L. Schmid [2] elevated level of government debt raise concerns about their impact on long-term growth prospects. Utilizing the cross-section of US stock returns, they illustrate that firms with significant R&D investment are more exposed to government debt and yield greater anticipated returns compared to those with minimal R&D investment, and heightened debt-to-GDP ratios forecast heightened risk premiums for firms with substantial R&D investment.

According to Th. Geelen, J.Hajda, E. Morellec [3] innovative firms heavily depend on debt financing. The study delves into the connection between debt financing, innovation, and growth within a Schumpeterian growth framework, wherein firms' ongoing R&D efforts and financing decisions are interlinked and internally determined. It reveals that while debt can impede innovation among established players due to the burden of existing debt, it also encourages new market entrants, thereby fostering innovation and overall growth. Additionally, the study highlights significant impacts of debt financing on factors such as firm entry, turnover, the structure and evolution of industries. Finally, it anticipates considerable variations within industries in terms of both leverage and innovation, aligning with empirical observations.

S. D'Andrea [4] examines the correlation between national debt and technological advancement using panel threshold regressions across a dataset encompassing 15 developed nations spanning from 2000 to 2019.

Additionally, the author investigates the influence of debt monetization, indicated by the volume of debt held by the central bank, on this connection. The findings reveal significant nonlinear patterns: surpassing a certain threshold, an escalation in debt adversely affects innovation rates, whereas remaining below it yields positive outcomes. Debt monetization enhances innovation if it stays below the "debt turning point", but this effect reverses for debt-to-GDP ratios exceeding the threshold.

J.Hajda, Th. Geelen, E. Morellec in article "Can Corporate Debt Foster Innovation and Growth" [5] indicated that forward-thinking companies heavily lean on debt funding. Debt overhang, in essence, obstructs innovation among established players. Conversely, another consequence of debt is its encouragement of innovation among newcomers. Employing a Schumpeterian growth framework incorporating internally determined R&D and financing decisions, we establish that this latter consequence consistently outweighs the former, thus promoting innovation and overall growth. Their examination intimates that the association between debt and investment possesses a complexity greater than previously recognized, shedding light on potential constraints within empirical investigations that exclusively target incumbents when assessing the impact of debt on investment.

X. Zhang, R. Jin [6] examined the influence of local government debt on enterprise innovation, drawing on data from A-share non-financial enterprises listed on the Shanghai and Shenzhen Stock Exchanges between 2011 and 2017. The findings reveal that the correlation between government debt and enterprise innovation follows an inverted U-shaped trajectory. Through meticulous handling of endogeneity and robustness testing, the model constructed for this investigation validates the results. Analysis of heterogeneity reveals that the inflection points of local government debt are lower in large enterprises, non-state-owned enterprises (non-SOEs), and regions with limited financialization. Financing constraints and corporate profits act as intermediary factors in the inverted U-shaped relationship between local government debt and enterprise innovation. Moreover, further exploration indicates that digital finance plays a moderating role in the impact of local government debt on enterprise innovation.

M. Coccia [7] analyzed the relationship between employment and innovation, also considering the interaction of the public debt among countries members of the EU. Thus, an increase of public debt has a negative effect for employment rate as well as for technology innovations. Economic growth drives an increase in the employment rate, with innovation being a key factor in both employment and economic growth. During times of economic turmoil, policymakers face a critical trade-off: they must choose between supporting R&D spending to boost employment and economic growth or adhering to balanced-budget rules to reduce public debt. The latter option, which involves cutting government spending including R&D investment, can negatively impact economic growth patterns.

J. Fan, Y. Liu, Qi Zhang and P. Zhao [8] find that government debt reduces firms' R&D expenditures among Chinese companies and lowers the number of new patents they produce. A likely explanation is that government debt increases firms' capital costs, limiting their innovation activities. The authors observe that innovations in financially constrained firms – such as small firms and those

with low cash flow – are more adversely affected by the increase of government debt. The results suggest that while government deficit spending may stimulate the economy in the short term, it could have negative consequences for economic productivity in the long term.

This study, of course, serves as a starting point for further investigations that will utilize more complex and comprehensive models.

Objectives of the article. The purpose of the article is to determine the impact of public debt accumulation on investment in innovations and economic value added among countries of the world. To achieve the outlined goal, the following research tasks need to be addressed: 1) Determining the basic economic indicators; 2) building the clusters; 3) conducting estimation based on SPSS platform.

Summary of the main results of the study. A primary outcome of the growth of the public debt is the increase in the cost of servicing it. Governments must allocate substantial funds toward interest payments on loans, potentially curtailing investment opportunities in alternative sectors. Instead of investing in infrastructure, education and innovation, governments will be forced to spend more on debt service. A large debt can lead to a loss of investor confidence, an increase in loan rates and further aggravation of the situation. A high level of public debt can reduce investment activity in the country. Investors may hesitate to inject funds into the economy of a heavily indebted country due to the associated high risk. Because of the high risk involved. Consequently, capital investments may decline, constraining the growth of enterprises and innovative initiatives.

Based on data from the World Bank [9], we are able to select the latest indicators of investments in various sectors of the economy in research and development. Moreover, if there is no such data for the coming years, then we do not include such a state in our analysis. Also available from the same source are GDP per capita, economic value added and public debt for at least 2022. Based on all the specified variables and the corresponding P packages, we divide 34 states into clusters. We choose the number of clusters that allows us to best differentiate states by state god. If states with a comparable level of debt fall into the cluster, we believe that there is no significant relationship between debt and various types of investments in research and development. Further, on the basis of regression analysis, using all possible types of curves to determine the nature of possible interdependencies, we answer the same question. If there is no such connection with the state debt, we try to test its presence with the economic added value (EVA).

The situation in the world with public debt is significantly differentiated among the countries. We have both obvious creditors and obvious debtors. For example, the provision of its own natural resources, institutional perfection (the leader in the All-inclusive economy in the world) allows Norway actually to be considered as the leader in the world in terms of public debt (Table 1). Italy, Japan, Spain, and a number of other countries are in the opposite situation, which, at the same time, is not a problem if the country's economy is characterized by stable, unchanging dynamics.

Based on the indicators and factors for clusterization shown above, Figure 1 represents graphical interpretation of the created clusters.

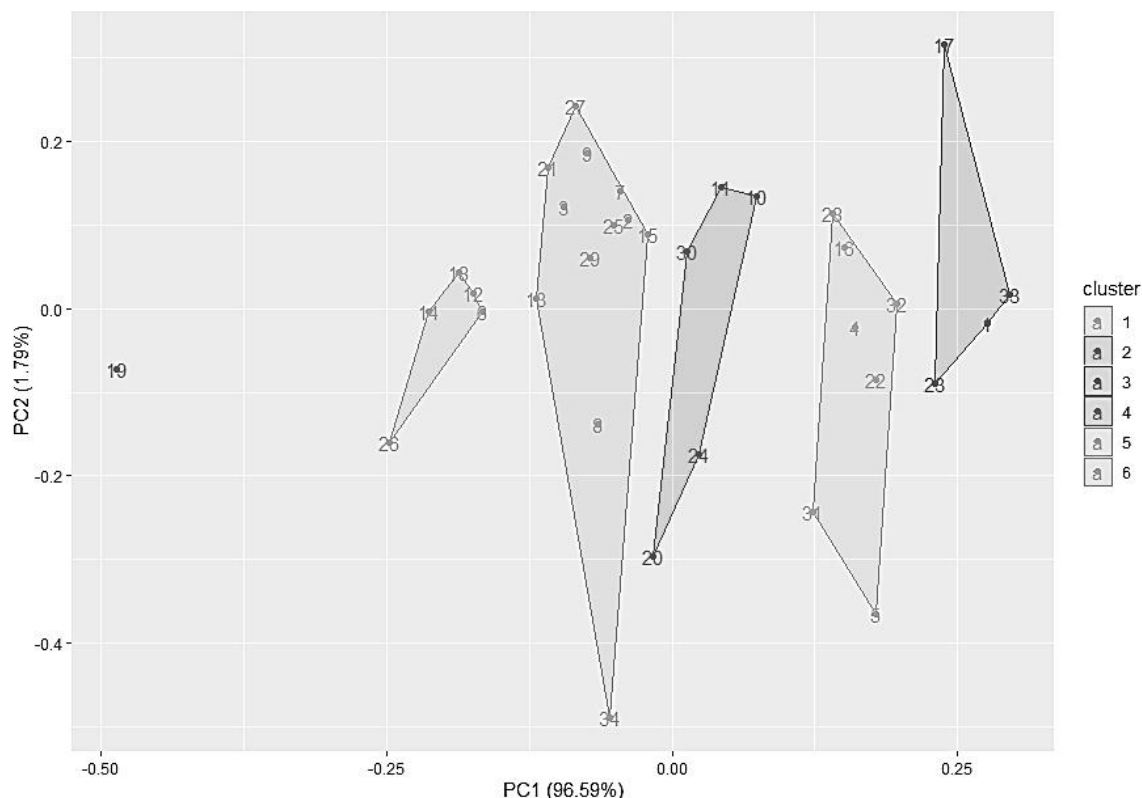


Figure 1. Graphical presentation of clusters

Notes: it was used libraries stats, dplyr, ggplot2, ggfortify, and clust of R.

Source: [10]

Table 1

R&D investment, EVA and Public Debt

Indicator	GERDP	BERDP	HERDP	GOVERDP	PSERDP	GDPP	VAE	PD
Australia (1)	2,19	1,23	0,58	0,24	0,86	3,05	12,51	0,346
Austria (2)	2,86	1,95	0,73	0,15	0,87	2,22	31,64	0,61
Belgium (3)	2,24	1,52	0,52	0,18	0,7	1,53	35,03	0,94
Canada (4)	1,69	0,88	0,65	0,15	0,8	2,6	19,54	0,32
Chile (5)	0,35	0,11	0,12	0,01	0,14	4,92	18,46	0,2
Czech Republic (6)	1,88	1,01	0,52	0,35	0,86	2,27	39,39	0,26
Denmark (7)	2,98	1,96	0,95	0,07	1,01	1,9	32,01	0,11
Estonia (8)	2,19	1,26	0,7	0,2	0,91	3,95	33,22	0,04
Finland (9)	3,55	2,44	0,77	0,32	1,09	1,94	33,78	0,34
France (10)	2,29	1,48	0,47	0,31	0,78	1,57	24,75	1,01
Germany (11)	2,98	2,02	0,53	0,43	0,96	1,96	26,64	0,47
Hungary (12)	1,3	0,85	0,24	0,19	0,43	1,65	39,91	0,7
Iceland (13)	2,61	1,38	0,69	0,46	1,15	2,77	36,55	0,6
Ireland (14)	1,66	1,2	0,38	0,08	0,46	2,16	42,28	0,5
Israel (15)	3,93	3,32	0,49	0,07	0,57	3,45	30,59	0,65
Italy (16)	1,27	0,69	0,36	0,17	0,54	1,42	20,08	1,38
Japan (17)	3,35	2,57	0,45	0,29	0,74	0,96	14,79	1,68
Korea (18)	4,36	3,4	0,41	0,49	0,91	3,99	40,64	0,21
Luxembourg (19)	1,46	1	0,18	0,28	0,46	2,33	58,89	-0,11
Mexico (20)	0,43	0,17	0,12	0,13	0,25	4,17	30,33	0,5
Netherlands (21)	2,16	1,22	0,7	0,23	0,94	0,87	35,91	0,43
New Zealand (22)	1,26	0,57	0,4	0,29	0,69	2,85	18,41	0,15
Norway (23)	1,65	0,86	0,52	0,27	0,79	3,14	15,3	-0,87
Poland (24)	0,9	0,33	0,31	0,25	0,56	3,33	27,89	0,41
Portugal (25)	1,5	0,7	0,58	0,1	0,68	1,11	32,41	1,2
Slovak Republic (26)	0,82	0,34	0,28	0,2	0,48	2,92	44,35	0,51
Slovenia (27)	2,63	1,99	0,29	0,34	0,64	0,63	34,4	0,5
Spain (28)	1,3	0,69	0,36	0,25	0,61	0,98	20,73	1,03
Sweden (29)	3,41	2,31	0,92	0,16	1,09	3,04	33,62	0,09
Switzerland (30)	2,87	2,17	0,88	0,02	0,9	2,7	28,47	0,22
Türkiye (31)	0,92	0,42	0,4	0,1	0,51	4,14	21,79	0,34
United Kingdom (32)	1,73	1,1	0,46	0,14	0,6	2,49	17,31	0,84
United States (33)	2,79	1,95	0,39	0,34	0,73	3,38	11,29	1
China (34)	1,98	1,51	0,15	0,32	0,47	7,47	32,63	0,83

Notes: debt as % of GDP for 2022. Factors for clusterization: GOVERD – government expenditure on R&D, BERD – business expenditure on R&D, HERD – higher educational expenditure on R&D, PSERD – public sector expenditure on R&D (as percentage). For these indicators, the nearest possible period is taken, when the relevant World Bank data became available. VAE % stands for Value Added (Economic) % and is the profit on the investment described in a suitable format for external investors in the business. PD is a public debt divided by GDP.

Source: own estimation based on World Bank [9]

Among all proposed by package NbClust of R indices:

10 proposed 2 as the best number of clusters; 5 proposed 3 as the best number of clusters; 1 proposed 4 as the best number of clusters; 1 proposed 5 as the best number of clusters; 3 proposed 6 as the best number of clusters; 1 proposed 8 as the best number of clusters; 1 proposed 9 as the best number of clusters; 1 proposed 10 as the best number of clusters. This library traditionally used the methods K-means, ward.D and centroid.

Using graphical presentation, our need in possibly biggest amount of clusters, and different methods we agreed with the choice 6 clusters (Figure 2).

Based on the distribution of cluster participants (Figure 3), we can see that there is no clear relationship between debt and the ability to increase investment in innovation. At the same time, regarding the 6th cluster,

the conclusion is suggested that both the actual status of the creditor and the status of the largest debtor are not an obstacle for active innovative activity.

The hypothesis we mentioned can be tested on the basis of regression curves (Table 2). Only in one case will we get a positive result.

Do we have some relation between Economic Value Added and public debt?

This means that for a significant part of the sample (12%), the growth of debt first allows the accumulation of funds for the formation of added value, and then servicing the debt destroys further growth. In all other cases significance of F criterion isn't sufficient.

Next proposed testing is showing that there is no significant relationship between investment in research and development and public debt, as it shown in

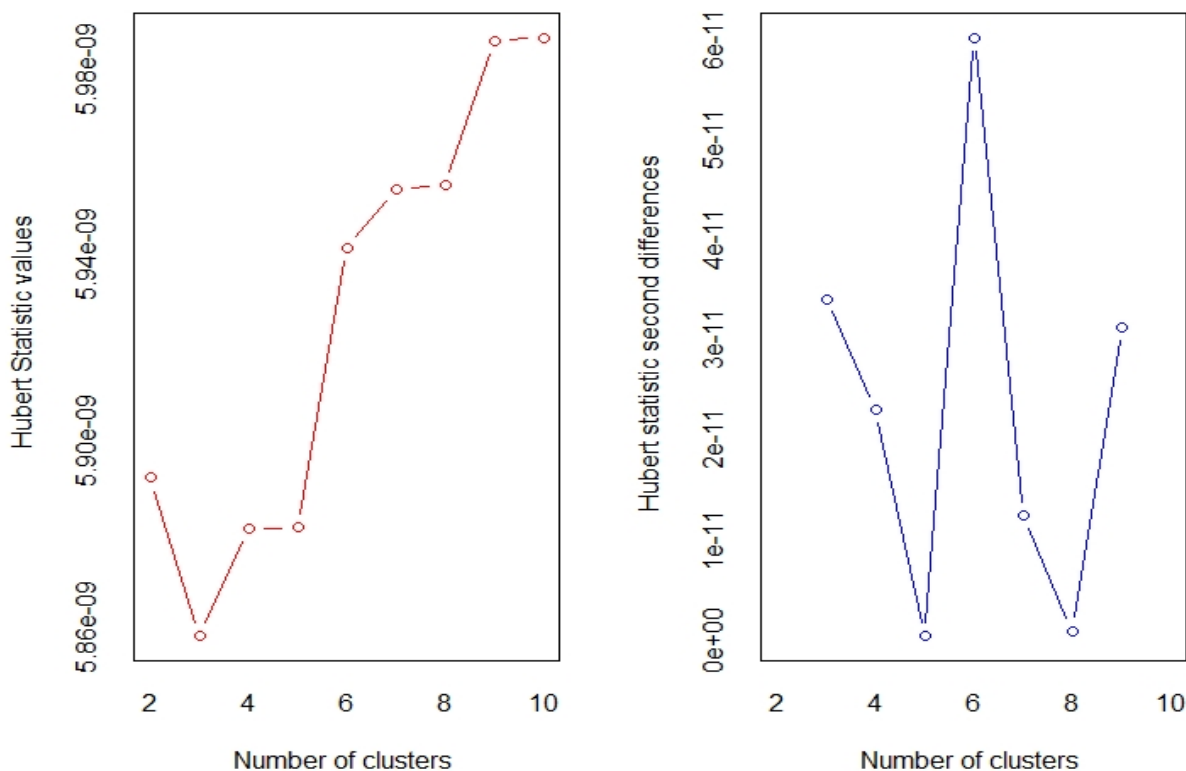


Figure 2. Number of clusters determination

Note: In the case of Hubert index, we seek a significant knee that corresponds to a significant increase of the value of the measure or the significant peak in Hubert index second differences plot.

Source: authors' processing

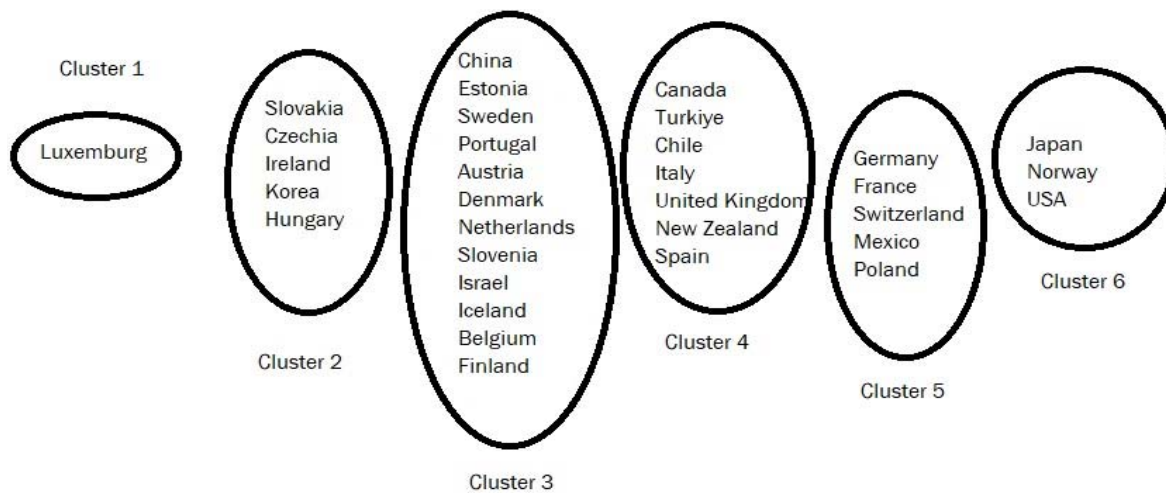


Figure 3. Distribution of countries by clusters

Source: authors' processing

Table 3 for government investment and in Table 4 for business investment.

Conclusions. Overall, public debt presents a multi-faceted challenge that requires effective management. Although it can be a useful tool for financing important projects and maintaining economic stability, uncontrolled debt growth can have serious consequences for a country's economy. Thus, the accumulation of public debt for various purposes may in some cases contribute to a temporary

increase in economic value added in the economy, but does not contribute to either government investment in innovation or (indirectly) business investment in research and development. A policy directed at the accumulation of public debt can have only temporary gains (social component, strengthening of the defence sector during preparations for war, etc.). Transferring it to the status of a long-term instrument destroys the economy's ability to develop and innovate. Thus, only the balanced debt policy

Table 2

Testing by curves the relationship between added value and public debt

Equation	R Square	F	Sig.	Constant	b1	b2	b3
Linear	,042	1,414	,243	31,624	-4,570		
Quadratic	,164	3,044	,062	31,311	4,502	-9,094	
Cubic	,175	2,115	,119	32,624	2,574	-13,207	3,573
Exponential	,032	1,042	,315	29,497	-,146		

Notes: Dependent Variable: EVA. The independent variable is PD.

Source: own estimation based on SPSS platform

Table 3

Government investment in R&D and public debt

Equation	R Square	F	Sig.	Constant	b1	b2	b3
Linear	,000	,006	,937	,221	,004		
Inverse	,022	,715	,404	,234	-,004		
Quadratic	,005	,081	,922	,222	-,018	,021	
Cubic	,007	,068	,977	,216	-,009	,039	-,016
Compound	,009	,307	,584	,163	1,187		
S	,022	,726	,401	-1,653	-,025		
Growth	,009	,307	,584	-1,814	,172		
Exponential	,009	,307	,584	,163	,172		

Notes: The independent variable is PD. Dependent Variable: GOVERDP.

Source: own estimation based on SPSS platform

Table 4

Business investment in R&D and public debt

Equation	R Square	F	Sig.	Constant	b1	b2	b3
Linear	,007	,216	,645	1,296	,146		
Inverse	,010	,310	,582	1,322	,016		
Quadratic	,007	,105	,901	1,295	,156	-,010	
Cubic	,043	,449	,720	1,492	-,132	-,625	,535
Compound	,011	,344	,562	,987	1,190		
S	,005	,145	,705	,045	,011		
Growth	,011	,344	,562	-,013	,174		
Exponential	,011	,344	,562	,987	,174		

Notes: The independent variable is PD. Dependent Variable: BERDP.

Source: own estimation based on SPSS platform

is a guarantee of innovative development of the country. Governments should capitalize on periods of economic expansion to embark on debt reduction endeavors. Equally imperative is the promotion of fiscal policies that instill confidence in investors and demonstrate long-term stability

and solidity. By implementing such preventive measures, forward-thinking governments can better navigate unforeseen financial problems, maintaining greater flexibility and minimizing disruptions to innovation processes, unlike states saddled with unmanageable debt burden.

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