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FORECASTING THE INNOVATIVE AND DIGITAL STRENGTH OF UKRAINE'S ECONOMY ON THE BASIS OF CORRELATION-REGRESS ANALYSIS*

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Abstract. The *purpose* of the research is to present the realised forecasts of Ukraine's economic power in order to find reserves for the recovery of the national economy and opportunities for the formation of digital entrepreneurship on the basis of innovative functioning, which will lead to economic growth in the medium and long term. The *object* of scientific research is the expenditure on SRD and S&T development by types of work in Ukraine from 2010 to 2022 and the analysis of indicators of GDP the influence of time, employment and inflation factors; expansion of digital capabilities of entrepreneurship due to the conducted R&D, which will become a guarantee of the emergence of breakthrough innovations as one of the key reserves of innovative and digital development of the country during the war and post-war reconstruction of Ukraine. *Methodology.* A study was conducted utilising dialectical, systematic, mathematical and statistical methods to investigate the R&D expenses by types of work in Ukraine from 2010 to 2022 and the GDP from 2011 to 2023. This analysis determined the prospective existing reserve of economic strength with positive dynamics and highlighted the necessity for a strategic format of digital business work based on innovation. A CRA was conducted to determine the strength of the relationship between SRD expenditures and time (i.e., a set of factors that consistently influence SRD funding and drive its growth trend). Fisher's test was calculated, and an econometric analysis was performed based on GDP indicators over 56 quarters, establishing the dependence of the GDP volume on the time factor and the cyclicality of seasonal fluctuations. *Resluts.* The conditions for accelerating the digitisation of business processes at domestic enterprises are, in particular, the presence of highly qualified S&R personnel, innovators and researchers in the country, the development of new institutes of innovative and digital development, and the transformation and adaptation of old institutes of development to the existing conditions. The obtained data of CRA show that there is a close relationship between the GDP of Ukraine and the time factor, and the direction of the relationship is direct, i.e., linear, which in this case is a positive fact. It is determined that in pursuit of the goal of restoring the innovative potential of the national economy in the post-war period and further active development of digital entrepreneurship in Ukraine, it is necessary to continue financial support for scientific research and scientific and technical developments carried out in various sectors of the economy. *Practical implications.* The analysed statistical data had a positive impact on the professionalism of the forecast calculations and allowed to state that in 2027, with a probability of error of 6.29%, the volume of expenditures on research and development is projected to range from 20,202.74 to 29,201.18 million UAH. The results of the CRA show that the multiple correlation coefficient (R) is 0.94, which indicates a close overall relationship between the country's GDP and three independent variables (inflation rate, unemployment rate, time factor). The linear regression equation fits the sample data well and the model is qualitative. The results of the forecast are as follows: Ukraine has the potential for post-war recovery and can develop models

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for post-war economic reconstruction and changes in its structure. Government officials can develop institutional instruments to attract investment and provide effective mechanisms for the future transformation of the existing labour market and human capital institution. *Value / Originality.* Having conducted a thorough analysis of the statistical data on the dynamics of spending on S&T development and implementation of the SRD in Ukraine in 2010-2022, the authors managed to determine the relative error of approximation – a criterion for assessing the reliability of the forecast, which amounted to 8.74% and considered the approximation to be qualitative, and the forecast for 2027 is reliable. It is determined that the regression equation is most accurate when R^2 approaches its maximum value, that is, 1, and in this case, it is 0.9096, which is a good result and means that the linear regression equation fits the sample data well and the model is of high quality. And for Ukraine's economy, which is under martial law, such positive expectations for GDP and the possibility of increasing R&D spending give hope that Ukraine's economic strength is real, as confirmed by the forecast calculations.

Keywords: economic potential, R&D, expenditure on S&T development, correlation-regression analysis, GDP, econometric analysis, digital entrepreneurship, innovative development, inflation, employment, time factor, economic growth.

JEL Classification: D92, C53, E59, F43, M13

1. Introduction

The post-war recovery of Ukraine's economy is possible only if it is innovated and digitalised, and the national innovation market is developed, which would feature the latest products, services and inventions created by Ukrainian innovators and produced and scaled up by domestic enterprises. The authors are convinced that Ukraine's economic growth is in the coordinate system of digital entrepreneurship, start-ups, increased exports of domestic products and private consumption, and the development of sustainable development tools. The continuous improvement of existing business "rules of the game" cannot be ignored. It is worth focusing on the simplicity of doing business. Currently, it is important for both heavy and light industries, as well as for agricultural businesses, the healthcare industry and the financial and banking sector, among others.

In order to realise the innovative and digital development of the Government of Ukraine, it is necessary to pay due attention to the research personnel, both morally and financially. It's the researchers in the laboratories who generate ideas, conduct experiments and possess unique experimental samples of their inventions. Intellectual capital of Ukraine is "chased" by a number of post-industrial, innovative countries, and in their own country neither they nor their inventions are "undervalued", which is the reason why Ukraine is lagging behind in innovative development. Sometimes scientists have to implement their ideas on a test sample not because of them, but in spite of them, because the "price of the issue" is high, and researchers simply do not have the funds to do so. The reasons are as follows:

– The government does not consider this a priority for funding due to a lack of foresight and does not have complete reliable information on the value of domestic inventions and developments.

– Firstly, businesses observe a lack of trust in the government. This is due to the belief that as long as there are no economic consequences, they are "untouched" by various state controlling institutions. Conversely, when economic benefits emerge, businesses encounter inadequate protection of their intellectual property rights and a fragile institution of intellectual property ownership. Secondly, businesses are reluctant to wait for economic benefits due to intense competition, dynamic shifts in the business environment, market conditions, and shifts in consumer preferences.

The implementation of any proposed models of war and post-war economic recovery in Ukraine is contingent upon the availability of highly qualified research personnel, innovators, and researchers within the country. Additionally, the development of innovative businesses and the formation of digital entrepreneurship are prerequisites. Furthermore, the establishment of new institutes of innovative and digital development and transformation, as well as the adaptation of existing institutes of development, are essential. Finally, the creation of a favourable "investment climate" and the development of fair, stimulating "rules of the game" for digital business are necessary conditions for success.

2. Literature Review

Noted scientists are engaged in original research and disseminate their findings as part of the country's economic development strategy. In 1987, scientists R. Cooper and E. Kleinschmidt conducted research into the success factors inherent in innovative products. They noted that innovative products are characterised by risk and are subject to a number of difficulties and failures on the way to scaling. The research conducted by M. Cuvero, M. Granados, A. Pilkington,

and R. Evans (2023) focused on the delineation of the developmental processes undertaken by high-tech entrepreneurs at the individual level and the evaluation of the absorption and implementation of knowledge in physical and virtual clusters within entrepreneurial ecosystems. In a study published in 2020, scientists V. Gupta, J. Fernandez-Crehuet, and T. Hanne found that startups could effectively manage innovation with relatively small teams, particularly when working in collaboration with freelancers. This approach enables team members to gain new skills, enhance their existing abilities, and adopt a more expansive perspective regarding their markets. In a study conducted by researchers N. Tripathi, M. Oivo, K. Liukkunen, and J. Markkula in 2019, it was demonstrated that internal sources are the most prevalent for identifying the requirements for the product idea in the context of minimum viable product (MVP) development. The findings suggest that support factors, such as incubators and accelerators, can influence MVP development by providing young founders with the necessary entrepreneurial skills and education to create the right product to meet market needs.

A. Bitektine and P. Haack (2015) developed a multilevel theory of the legitimacy process in their publication, "The 'macro' and the 'micro' of legitimacy: toward a multilevel theory of the legitimacy process." They did so under the conditions of an ideal type of institutional stability and institutional changes. They also studied the dynamics of institutional changes, from the destabilisation of the institutional order to the return to stability in legitimacy. Viewing institutional stability as a state of suppressed diversity at the micro-level, A. Bitektine, P. Haack (2015) drew attention to "silenced" legitimacy judgments and judgment suppression factors that induce evaluators to refrain from making their deviant judgments public.

The conceptual principles of structural level modelling were put into practice by such esteemed scientists as J. Anderson and D. Gerbing (1988). They presented a comprehensive two-stage modelling approach that employs a series of nested models and highlighted the benefits of this approach over the one-stage approach. Furthermore, they distinguished between exploratory and confirmatory analyses. Researchers R. Bagozzi and L. Phillips (1991) worked on assessing construct validity in organisational research. They showed that Campbell and Fiske's criteria are deficient, particularly in their assumptions, diagnostic information and power. Confirmatory factor analysis (CFA) is shown to overcome most of the limitations inherent in Campbell and Fiske's procedures. However, two potential limitations of the CFA method have been identified. These are the confounding of random error with measure-specific variance and the inability to test for interactions between traits and methods (Bagozzi & Phillips, 1991). In his study, P. Bliese (2000) explored the concept of independence and the relationship between a form of intraclass correlation coefficient and eta-squared. He succeeded in broadening the scientific discussion of concordance, reliability and non-independence from an exclusive focus on validating one's own measurement model to a broader focus that includes testing substantive models and detecting emergent phenomena.

It is worthy of note that V. Biletskyi (2023) has made a significant contribution to the field of scientific research with his work on the methodology of studying technical objects and optimising them. The researcher presented the stages of the research work, revealed the content of the main scientific methods of setting up experiments and processing research results, and discussed the rationale behind their choice. Significant consideration was given to the registration of the results of the NDR and the organisational aspects of scientific activity.

A. Hayes (2022) in his work "Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach", using the principles of ordinary least squares regression, illustrates each step in an analysis with various examples from published studies, and displays SPSS, SAS, and R code for each example. He delineated the methodologies for estimating and interpreting direct, indirect, and conditional effects; probing and visualising interactions; testing hypotheses about the moderation of mechanisms; and reporting different types of analyses.

In their article, scientists C. Fuller, M. Simmering, G. Atinc, Y. Atinc and B. Babin (2016) present a data simulation which demonstrates that a relatively high level of CMV must be present in order to bias true relationships among substantive variables at typically reported reliability levels. The simulation data collectively indicates that at levels of construct-measure correlation (CMV) that are typical of multiple-item measures with typical reliabilities and reporting of typical effect sizes, CMV does not represent a significant threat to the validity of research findings.

The scientific literature on the digitisation of entrepreneurship and traditional businesses is reviewed by Professors P. Magliocca (2021), A. Botti, R. Parente, and R. Vesci (2021), as well as D. Herold (2022[a]; 2022[b]). These papers offer successful examples of the formation and development of digital ecosystems, ways of implementing start-up projects in different EU countries, and tools and mechanisms for rapid digitalisation of the economy based on digital entrepreneurship.

The issue of technology transfer and its impact on this process of state policy, the analysis of technological diversity, the study of the flow of knowledge and intellectual potential and its impact

on the emergence of industrial innovations, and the possibilities of scientific research to expand the innovative activity of firms were reflected in the studies of scientists such as B. Bozeman (2000), C. Chen, B. Lin, J. Lin, Y. Hsiao (2018), K. Girotra, C. Terwiesch, K. Ulrich (2007), A. Nerkar, S. Paruchuri (2005), and others.

The team of scientists K. Hoisl, M. Gruber, A. Conti (2017) investigate the impact of the composition of the research team on the results of its work in a hypercompetitive environment. They show that the role of experience diversity in R&D teams varies according to the size of the organisations in which R&D teams operate. In their publication, researchers F. Bravo and N. Reguera-Alvarado (2017) employed a combination of agency theory and resource dependence theory to demonstrate that, irrespective of industry type and the specific expertise of R&D-intensive companies, board members with multiple directorships exert influence over R&D corporate strategies.

In the publication (Alam (Ed.), 2019), the financing behaviour of R&D investments in emerging markets is examined. In their study, A. Alam, M. Uddin, and H. Yazdifar (2019) employ institutional theory and panel data with generalised methods of moment (GMM) estimation for a sample of 302 firms from 20 countries over the period 2003–2015. Their findings indicate that emerging market firms tend to utilise internal funds for financing R&D investments. This study is of significant importance as it provides novel evidence on the financing of R&D investments in emerging countries, taking into account the institutional arguments pertaining to financing choices. Consequently, it should serve to guide stakeholders on the most appropriate sources of R&D financing.

Scientists G. Lanzolla, D. Pesce, and C. Tucci (2021) are actively studying the features of digital transformation of innovation and innovative products. They investigated the impact of digitisation and connectivity on the "digital transformation" of physical products and presented a "framework for managing product innovation in the digital age" (Lanzolla, 2021).

Among the Ukrainian researchers who study the peculiarities of the formation of digital entrepreneurship and the search for investments for the development of breakthrough innovations under martial law and industrialisation in the digitalised economy are the following: I. Babukh, V. Lisitsa, O. Novikova (2023), K. Kraus, N. Kraus, M. Hryhorkiv, M. Kuzmuk (2022), I. Ishchenko, Y. Radzikhovska (2023), O. Manzhura (2021). An analysis of these recent studies has shown that the concept of digital transformation of the economy has three main advantages: increasing the efficiency of existing infrastructure through synergies from the creation of digital enterprises; the emergence of qualitatively new digital business models; and increasing revenues or reducing costs in existing business models.

The *purpose of the publication* is to make forecasts of the economic power of Ukraine on the basis of CRA and to clarify the closeness of the relationship between the costs of R&D and the formation of digital entrepreneurship, the prospects for the development of innovations and the growth of GDP; to present the forecast volume of expenditures on SRD by types of work in Ukraine for 2027, having carried out an analytical alignment of the dynamic series based on the analysis of data on expenditures on SRD in 2011-2022, the dynamics of Ukraine's GDP in 2010-2023 by quarter, and expenditures on S&T development in Ukraine from 2010 to 2022.

The *article includes the following tasks:* to explain the content of the forecast of the amount of SRD expenditures by types of Ukraine for 2027, to carry out an analytical adjustment of the dynamic series, and to present the results of an econometric analysis based on the data of the GDP of Ukraine for 2024-2025 by quarters; to reveal the results of the CRA in terms of identifying the dependence of the volume of GDP of Ukraine on the level of inflation and the level of unemployment in the country and on the time factor; to indicate the general trends traced in 2010-2022 in the dynamics of the share of expenditures on conducting scientific research in GDP; to reveal the content of practical recommendations for maintaining the further positive dynamics of expenditures on S&T development in Ukraine.

3. The State and Trends of Economic Activity of Business Entities

The innovative and digital development of any country directly depends on the amount of funding for research and development; the available human capital that generates innovative ideas; effective mechanisms for scaling up the latest developments; and efficient tools to support entrepreneurship in the country. General data as of April 1, 2024 on business entities in Ukraine (UkrStat, 2024[a]) are as follows:

– The total number of registered legal entities in Ukraine was 1,503,782.
– The number of registered individual entrepreneurs in Ukraine was 1,628,126.
– The number of registered legal entities engaged in technical testing and research is 2,153, research and experimental development in the field of biotechnology is 336, research and experimental development in the field of other natural and technical sciences is 4,286, and research and experimental development in the field of social sciences and humanities is 424.
– The number of registered individual entrepreneurs engaged in technical testing and research is 149,

research and experimental development in the field of biotechnology is 224, research and experimental development in the field of other natural and technical sciences is 1,733, and research and experimental development in the field of natural sciences and humanities is 975.

In order to achieve a comprehensive, in-depth and as accurate as possible disclosure of the topic of the publication, it is necessary to analyse the number of expenditures on S&T developments and research that took place in the economy of Ukraine from 2010 to 2023, inclusive (Figure 1). Thus, as of the end of 2022, expenditures on research and development in Ukraine amounted to 8,208.9 million UAH, which is 3,866.2 million UAH more than in 2010. However, it is worth noting that compared to 2021, in 2022, expenditures on research and development decreased by 2,776.1 million UAH. This is primarily due to the state of war in the country and the difficult socio-economic situation, which led to underfunding of most sectors of the national economy in 2022 and 2023. The aggregate expenditure on S&T developments in Ukraine over a 12-year period is 92,196.1 million UAH, in comparison to the total amount of expenditure on SRD over the same period, which amounted to 170,781.6 million UAH.

Despite a positive trend line for expenses related to the implementation of SRD (Figure 2), there were occasional fluctuations in the indicators over a 12-year period. These included downward movements in 2014, 2020 and 2022. The greatest expenditure was recorded in 2021, amounting to 20,923.1 million UAH. In 2022, a decrease of 3,805.3 million UAH was observed, yet the total remained higher than that of 2020 by 95.4 million UAH. It is also noteworthy that there is a systematic excess of costs associated with SRD over those associated with S&T developments, on average, by a factor of two each year.

With the aim of restoring the innovative potential of the post-war national economy and further active development of digital entrepreneurship, Ukraine should continue to financially support scientific research and S&T development in various sectors of the economy. The authors are convinced that such a decision can become strategic for the breakthrough innovative and digital development of small, medium and large enterprises in the medium and long term. The experience of the world's leading countries has shown that it is research, development and project activity that create an innovative and digital economy, with innovative entrepreneurship and digital production and industry. And if the total volumes of SRD and technical development expenditure analysed in Figures 1 and 2 show a generally positive dynamic, the indicators of the share of SRD expenditure in GDP from 2010 to 2022 show a negative dynamic (Figure 3).

4. Dynamics of the Country's GDP and Forecasting its Volume by CRA Methods

In 2022, the share of SRD expenditures in Ukraine's GDP was 0.33%, which is 0.42% less than in 2010. The trend line has been downward since 2010 to date. The paradox of this situation is that from 2010 to 2023, GDP dynamics were positive (Figure 4).

Thus, it seemed that with the growth of GDP, the government should pursue a policy of financial and economic support for research and development and increase the share of expenditure on research and S&T development and basic research. This is due to the undeniable fact that R&D support is always about the long-term perspective, the country's innovative development strategy, digital entrepreneurship and high technologies that can produce and scale large enterprises. An analysis of the data in Figure 4 and Figure 3 shows that in 2022 the ratio of GDP to SRD

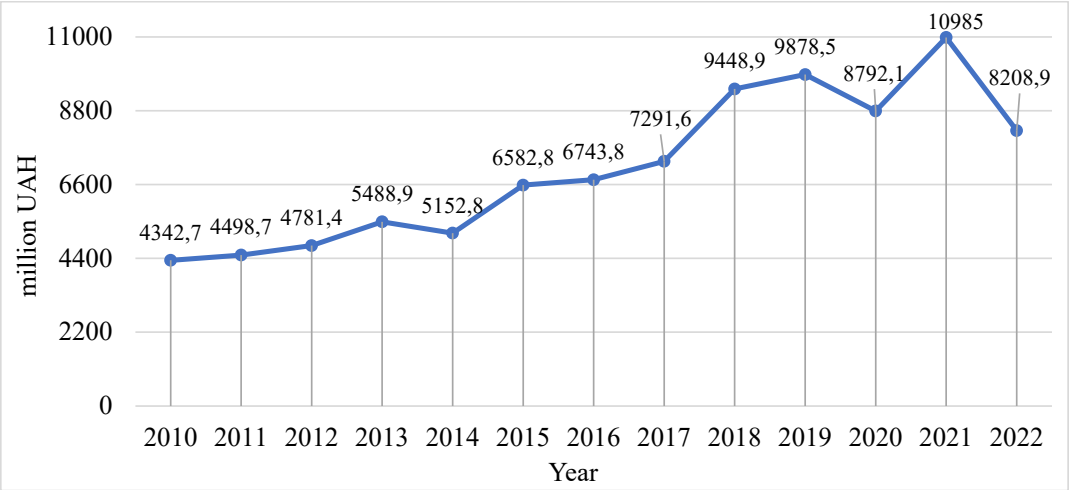

Figure 1. Expenditures for S&T developments in Ukraine from 2010 to 2022, million UAH
Source: compiled on the basis of data from the source (UkrStat, 2024[b])

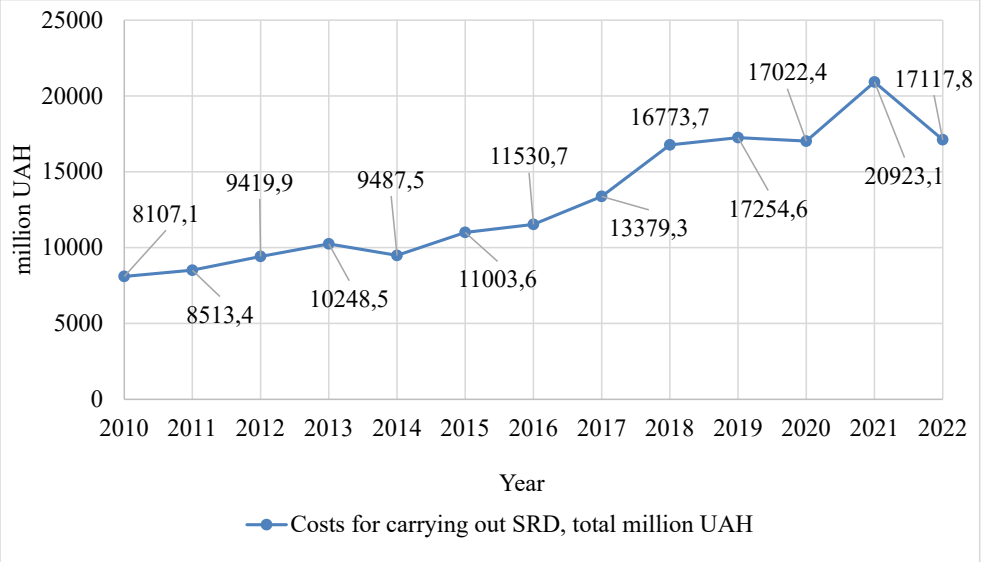

Figure 2. Expenditure on SRD, in Ukraine from 2010 to 2022, million UAH
Source: compiled on the basis of data from the source (UkrStat, 2024[c])

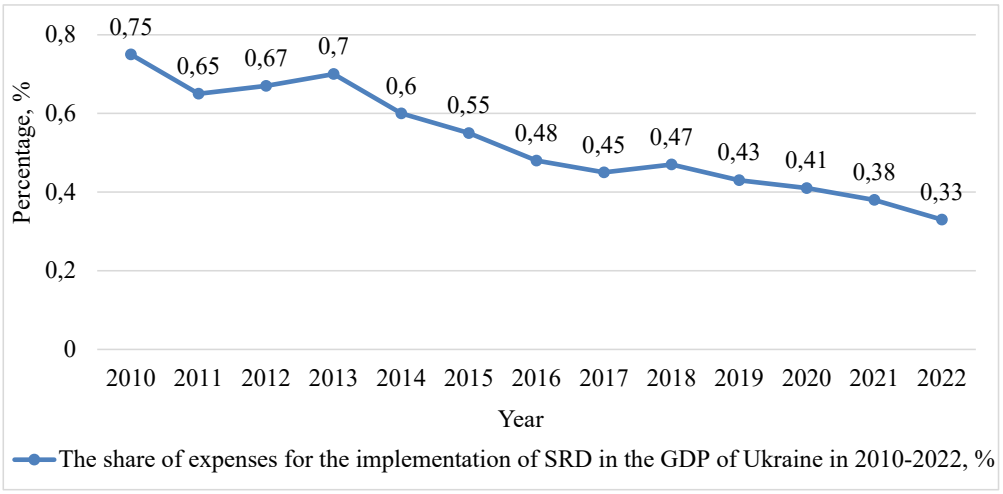

Figure 3. The share of expenditures on SRD in GDP 2010–2022 in Ukraine, %
Source: compiled on the basis of data from the source (UkrStat, 2024[b])

expenditures was 1:303, and in 2010 it was 1:133. This ratio has been deteriorating for all 12 years presented in Figure 3 and Figure 4.

The data analysis prompted the forecasting of some indicators, because when talking about the post-war recovery of Ukraine's national economy, it is worth having an idea of the forecast expectations in the short and medium term in order to develop tools for future strategies for Ukraine's innovation and digital development based on knowledge-based breakthroughs, digital and high-tech manufacturing. Accordingly, the forecast volume of expenses for SRD by types of work in Ukraine for 2027 will be determined through an analytical alignment of the dynamic series. The data set includes annual expenditures on SRD by types of work in Ukraine for the period between 2011 and 2022 (Table 1).

Table 1
Expenditures on SRD by types of work in Ukraine in 2011–2022

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Costs for SRD, million UAH	8513,4	9419,9	10248,5	9487,5	11003,6	11530,7	13379,3	16773,7	17254,6	17022,4	20923,1	17117,8
	I				II				III			

Source: compiled on the basis of data from the source (UkrStat, 2024[b])

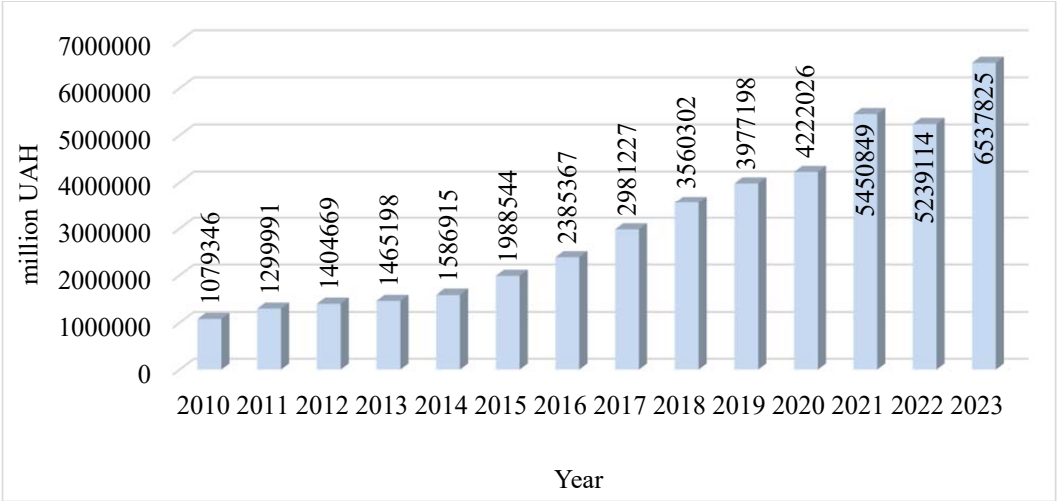

Figure 4. GDP in actual prices from 2010 to 2023 in Ukraine, million UAH
Source: *compiled on the basis of data from the source (UkrStat, 2024[d]; UkrStat, 2024[e])*

First, consider whether this time series is trending using the Cox-Stewart test. To do this, the series is divided into three equal parts and the corresponding terms of the last and first third are compared.

I: 8,513.4; 9,419.9; 10,248.5; 9,487.5.

III: 17,254.6; 17,022.4; 20,923.1; 17,117.8.

The following signs of differences between levels (YIII - YI) are obtained: +; +; +; +.

The levels of the III third are higher than the levels of the I third, and then the "pluses" accumulate, which means that the levels in the series tend to increase. Consider the form of the analytical expression of the relationship using the correlation field (Figure 5).

Visually, it can be concluded that the points fluctuate around a straight line, so the trend is approximated by a straight line:

$$\hat{y}_t = a + b \cdot t. \quad (1)$$

Since the number of levels in the series is even n=12, time is ranked from 1 to n (by ordinal number). Calculation of the parameters of the trend equation (Table 2).

$$an + b\sum t = \sum y$$
$$a\sum t + b\sum t^2 = \sum yt$$
$$b = 1061{,}5$$
$$a = 6656{,}46$$
$$\hat{y}_t = 6656{,}46 + 1061{,}5 \cdot t.$$

Explanation of the parameters of the trend equation: parameter a=6,656.46 is the value of SRD expenditures in the "zero" period (in 2010); parameter b=1,061.5 is the annual increase in SRD expenditures in million UAH. The "+" sign in front of the b parameter means increasing the levels of the series.

The next step is to check the closeness and materiality of the relationship:

a) Calculation of the linear correlation coefficient:

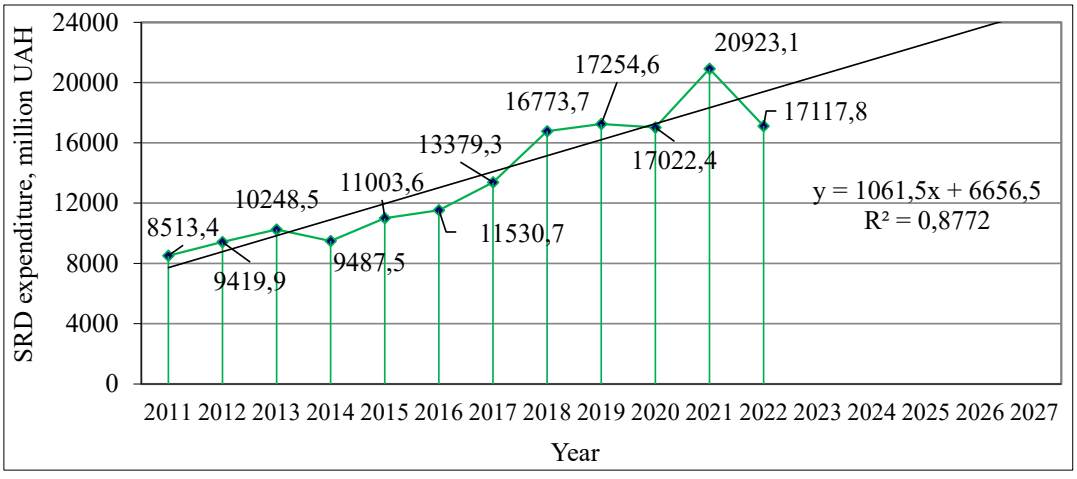

Figure 5. Correlation field
Source: compiled on the basis of data from the source (UkrStat, 2024[b])

Table 2

Calculation of parameters of the trend equation for forecasting SRD expenditures in Ukraine in 2011-2022

Year	t	y_i	t^2	yt	y^2	$\hat{y}_t$	$\lvert y_i - \hat{y}_t \rvert$	$(y_i - \hat{y}_t)^2$	$\frac{\lvert y_i - \hat{y}_t \rvert \cdot 100}{y_i}$
2011	1	8 513,4	1	8 513,4	72 477 979,56	7 717,96	795,44	632 724,79	9,34
2012	2	9 419,9	4	18 839,8	88 734 516,01	8 779,46	640,44	410 163,39	6,80
2013	3	10 248,5	9	30 745,5	105 031 752,25	9 840,96	407,54	166 088,85	3,98
2014	4	9 487,5	16	37 950,0	90 012 656,25	10 902,46	1 414,96	2 002 111,80	14,91
2015	5	11 003,6	25	55 018,0	121 079 212,96	11 963,96	960,36	922 291,33	8,73
2016	6	11 530,7	36	69 184,2	132 957 042,49	13 025,46	1 494,76	2 234 307,46	12,96
2017	7	13 379,3	49	93 655,1	179 005 668,49	14 086,96	707,66	500 782,68	5,29
2018	8	16 773,7	64	134 189,6	281 357 011,69	15 148,46	1 625,24	2 641 405,06	9,69
2019	9	17 254,6	81	155 291,4	297 721 221,16	16 209,96	1 044,64	1 091 272,73	6,05
2020	10	17 022,4	100	170 224,0	289 762 101,76	17 271,46	249,06	62 030,88	1,46
2021	11	20 923,1	121	230 154,1	437 776 113,61	18 332,96	2 590,14	6 708 825,22	12,38
2022	12	17 117,8	144	205 413,6	293 019 076,84	19 394,46	2 276,66	5 183 180,76	13,30
Total	78	162 674,5	650	1 209 178,7	2 388 934 353,07	162 674,52	X	22 555 184,95	104,89
Average value	6,5	13 556,2	54,17	100 764,89	199 077 862,76	13 556,21	X	1 879 598,75	8,74

Source: calculated by the authors

$$r = \frac{\overline{y \cdot t} - \overline{y} \cdot \overline{t}}{\tilde{A}_t \cdot \tilde{A}_y} \quad (2)$$

$$r = \frac{100\,764{,}89 - 13\,556{,}2 \cdot 6{,}5}{3{,}45 \cdot 3912{,}45} = 0{,}9371$$

The correlation coefficient (correlation ratio) indicates a close "connection" between SRD expenditures and "time" (i.e., a set of reasons that permanently affect the amount of SRD funding and determine the tendency for their growth).

b) Calculation of Fisher's criterion:

$$F_{calculated} = \frac{(r)^2}{1-(r)^2} \times \frac{k_2}{k_1} \quad (3)$$

where $k_1 = m - 1$, a $k_2 = n - m$;

n – number of population units under study (n=12);

m – number of parameters in the regression equation (m=2 (a and b));

$F_{calculated} = 72{,}03$.

Tabular (critical) value of Fisher's F-test at $\alpha = 0{,}05, p = 0{,}95$, $k_1 = 1, k_2 = 10$ is $F = 4{,}96$. Since $F_{calculated}(72{,}03)$ is greater than $F_{critical}(4{,}96)$, then the significance of the relationship is proven. Then, the forecast volume of expenditures on SRD for 2027, the rank of which will be $t = 17$: $\widehat{y_{17}} = 6656{,}46 + 1061{,}5 \cdot 17$, $\widehat{y_{17}} = 24\,701{,}96$ million UAH, but this is a point forecast.

This is how the calculation of the standard deviation of the model appears:

$$S_e = \pm\sqrt{\frac{\Sigma\left(y_i - \widehat{y_t^2}\right)}{n-m}} \times \sqrt{\frac{n+1}{n} + \frac{3 \times (n + 2\upsilon - 1)^2}{n \times (n^2 - 1)}}, \quad (4)$$

where: υ - the forecast shift period (υ = 5 years);

$S_e = \pm 2045{,}1$ million UAH

The marginal error of the forecast at $\alpha \approx 0{,}05$ " $= \pm t \cdot S_e$, where Student's t-test (for $\alpha \approx 0{,}05$ and n=11 $t_{tabular} = 2{,}20$):" $= \pm 2{,}20 \times 2045{,}1 = \pm 4499{,}22$.

Then, the interval forecast will be: $20\,202{,}74 \le \hat{y}17_{0{,}9371} \le 29\,201{,}18$.

In 2027, with a probability of error of 6.29%, the number of expenditures on SRD is projected to fall within the range of 20,202.74 to 29,201.18 million UAH. The authors also determined the relative error of approximation, which is a criterion for assessing the reliability of the forecast:

$$\overline{\mu} = \frac{1}{n} \sum \frac{\lvert y_i - \widehat{y_t} \rvert}{y_i} \cdot 100 \quad (5)$$

$$\overline{\varepsilon} = \frac{1}{12} \cdot 104{,}89 = 8{,}74\%.$$

Since $\overline{\varepsilon}$ does not exceed 15%, the approximation is considered qualitative, and the forecast is reliable. In order to develop the most effective strategies for the economic reconstruction of Ukraine on the basis of digital entrepreneurship, it is essential to accurately forecast the situation in the country's economy. This will enable the reduction of inflation, the strengthening of the national monetary unit, the reduction of the unemployment rate in Ukraine, and the development of effective tools to encourage the return of Ukrainians to their homeland. In order to achieve this, it is necessary to conduct another CRA, which will affect another group of indicators, but will allow the analysis to cover the spectrum of other factors.

5. Econometric Analysis of the Dependence of the Country's GDP on External Influencing Factors

It is pertinent to recall that the volume of a country's GDP serves as a macroeconomic indicator, enabling an assessment of the level of well-being experienced by citizens to a significant extent. An understanding of the dynamics of a country's GDP provides insight into the efficacy of the state's economy. An increase in GDP is indicative of economic growth, which in turn is associated with an expansion in production, an increase in the supply of goods and services, an increase in employment, and a reduction in unemployment. This ultimately leads to an increase in the purchasing power of the population. A decline in GDP is indicative of a reduction in domestic production, employment opportunities and income levels, as well as an increase in inflationary pressures. The turbulence of Ukraine's economic development in recent years has led to a growing necessity to consider the impact of the geo-economic situation, foreign policy, and internal shocks on GDP. In order to pursue the goal of "looking into the near future," an econometric analysis will be conducted on the basis of Ukraine's GDP data for the period between 2010 and 2023 (Table 3).

The authors used monthly GDP figures for their calculations – 56 periods (quarters) in total, and therefore tried to establish the dependence (influence) of the time factor and cyclic seasonal fluctuations on the country's GDP.

The CRA data obtained (Table 4) indicate a close relationship between Ukraine's GDP and the time factor. The conclusion about the closeness of the relationship is based on the value of the theoretical coefficient of determination (R^2) and the theoretical correlation coefficient (R). The coefficient of multiple correlation (R) for Ukraine is 0.9537, which indicates a close overall relationship between the country's GDP and the independent variable (time). The coefficient of determination (R^2) is in the range of $0 \leq R2 \leq 1$ and shows the overall quality of the model. The regression equation is most accurate when R^2 approaches its maximum value of 1, which in this case is 0.9096, meaning that the linear regression equation fits the sample data well and the model is good. Thus, there is a close relationship between Ukraine's GDP and the time trend factor, and the direction of the relationship is direct, i.e., linear.

Having found the coefficients of influence of the factors of each quarter and the trend (Time), consider a graphical representation of the forecast of Ukraine's GDP for 2024-2025 (by quarter) (Figure 6). Since the authors analysed quarterly data for 14 years, Figure 6 suggests that the shape of the curve is repeatable at equal time intervals, i.e., there is a clear presence of cyclicality (seasonal component). It is necessary to determine the presence of a cyclical component so that the input information has the property of representativeness.

When choosing parameters for forecasting the country's GDP, it is necessary to take into account that the forecasting horizon (the number of periods in the future covered by the forecast – in this case, it is 8 quarters) should be no less than the time required to implement the decision made on the basis of this forecast. Only in this case does the forecast make sense, and therefore it can be said that the forecast

Table 3
Ukraine's GDP from 2010 to 2023 by quarters

(In actual prices, million UAH)

Year	Quarter	GDP	Year	Quarter	GDP	Year	Quarter	GDP	Year	Quarter	GDP
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
2010	Q1	217074	2014	Q1	316905	2018	Q1	706141	2021	Q1	1019715
	Q2	255545		Q2	382391		Q2	809938		Q2	1182310
	Q3	300446		Q3	440476		Q3	994728		Q3	1512884
	Q4	306281		Q4	447143		Q4	1049495		Q4	1735940
2011	Q1	258591	2015	Q1	375991	2019	Q1	820006	2022	Q1	1091508
	Q2	310277		Q2	456715		Q2	932459		Q2	1030900
	Q3	368488		Q3	566997		Q3	1111962		Q3	1461098
	Q4	362635		Q4	588841		Q4	1112771		Q4	1655608
2012	Q1	292324	2016	Q1	455298	2020	Q1	858415	2023	Q1	1362537
	Q2	346005		Q2	535701						
	Q3	387109		Q3	671456		Q2	879921		Q2	809938
	Q4	379231		Q4	722912						
2013	Q1	303753	2017	Q1	591765		Q3	1173113		Q3	1463941
	Q2	354814		Q2	664307						
	Q3	398000		Q3	833640		Q4	1310577		Q4	1049495

Source: compiled on the basis of data from the source (UkrStat, 2024[d]; UkrStat, 2024[e])

Table 4

Results of the CRA dependence of Ukraine's GDP on the time factor

Regression statistics					
Multiple R	0,953756749	Normalised R-squared	0,902565813	Observation	56
R-squared	0,909651935	Standard error	142857,4589		
Analysis of variance					
	df	SS	MS	F	F Weight
Regression	4	1,04793E+13	2,61983E+12	128,3708978	5,75012E-26
Remainder	51	1,04082E+12	20408253557		
Total	55	1,15201E+13			
	Coefficients	Standard error	t-statistic	P-Value	
Y-intersection	150052,2761	52146,25189	2,877527543	0,005840082	
Q1	-225297,4348	54111,73427	-4,163559675	0,000120773	
Q2	-184220,7898	54046,93753	-3,408533364	0,001283356	
Q3	-38977,8592	54008,02218	-0,721704992	0,473771856	
Time	25723,42651	1183,919662	21,72734125	1,93656E-27	

Source: calculated by the authors

is highly reliable, as it covers 2 years. It should be borne in mind that as the forecasting horizon increases, the accuracy of the forecast tends to decrease, and as the horizon decreases, it increases, so the results are meaningful.

At the same time, the above forecast takes into account only one independent variable (the time factor), but the impact of other independent variables on the country's GDP, such as the inflation rate and the unemployment rate, should be considered. When conducting a second econometric analysis, the results are somewhat different (Table 5).

The results of the repeated CRA show that the multiple correlation coefficient (R) is 0.94, which indicates a close overall relationship between the country's GDP and 3 variables (inflation rate, unemployment rate, and time factor).

In this case, the coefficient of determination (R^2) is 0.8836, which is lower than in the previous analysis (Table 7), but also a fairly good result and means that the linear regression equation fits the sample data well and the model is of good quality. Re-finding the coefficients of the 3 independent variables allowed to graphically present another forecast of Ukraine's GDP for 2024-2025 (quarterly) under the influence of more factors (Figure 7).

The forecast accuracy required to solve a specific task (forecasting a country's GDP) is influenced by the forecasting system. The forecast error depends on the forecasting system used. This means that the more resources such a system has (data taken into account), the more likely it is to produce a more accurate forecast (quarterly data, inflation and unemployment rates in the country were used). However, forecasting

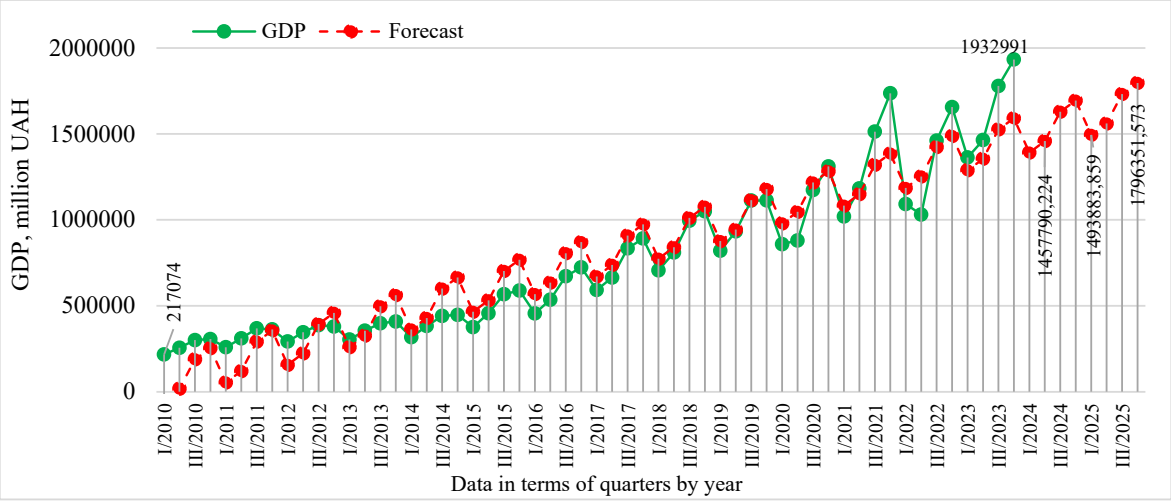

Figure 6. Dynamics of Ukraine's GDP in 2010-2023 and visual representation of forecast indicators for 2024-2025 (quarterly) under the influence of the time factor

Source: built on the basis of calculations

Table 5

Results of the CRA of the dependence of Ukraine's GDP on inflation and unemployment in the country and the time factor

Regression statistics					
Multiple R	0,94000878	Normalised R-squared	0,87690208	Observation	56
R-squared	0,88361651	Standard error	160573,025		
Analysis of variance					
	df	SS	MS	F	F Weight
Regression	3	1,0179E+13	3,3931E+12	131,599596	2,8411E-24
Remainder	52	1,3408E+12	2,5784E+10		
Total	55	1,152E+13			
	Coefficients	Standard error	t-statistic	P-Value	
Y-intersection	1721138,61	609161,56	2,82542223	0,0066828	
Inflation index	-1669225,2	600499,177	-2,7797293	0,00755566	
Unemployment rate	-276057,86	554925,564	-0,4974683	0,620956	
Time	25791,8306	1670,02862	15,4439452	4,5355E-21	

Source: calculated by the authors

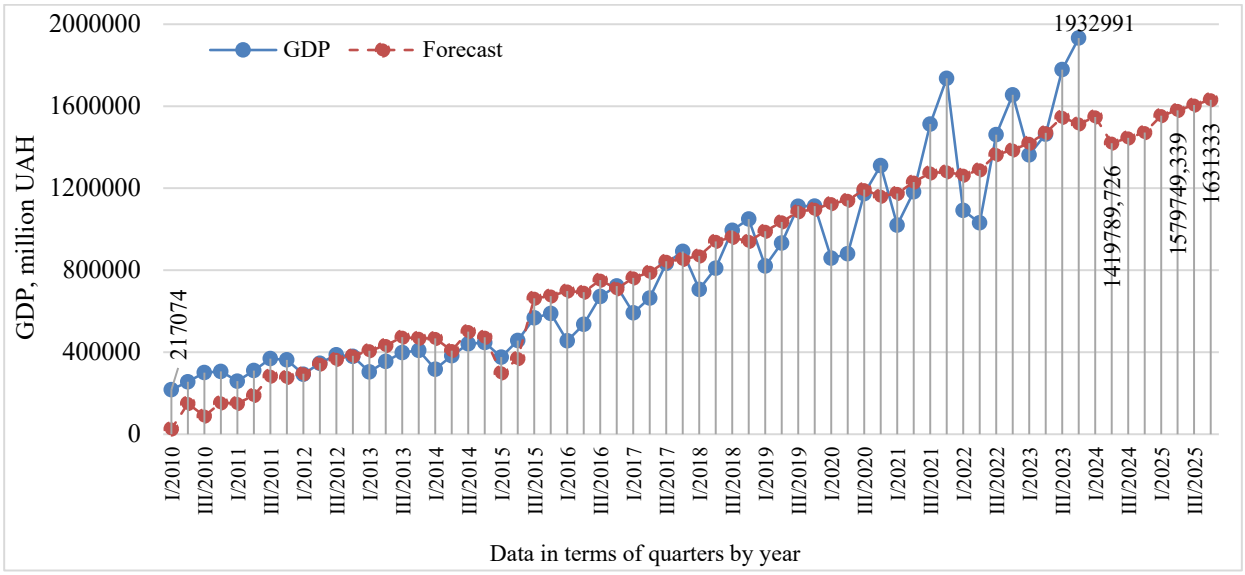

Figure 7. Dynamics of Ukraine's GDP for 2010-2023 and visual representation of forecast indicators for 2024-2025 (quarterly) under the influence of inflation and unemployment in the country, time factor

Source: built on the basis of calculations

cannot completely eliminate risks in decision-making, so a possible forecasting error is always taken into account.

Ukraine has the potential for post-war recovery and can develop models for post-war economic reconstruction and changes in its structure. Government officials can develop institutional tools to attract investment and provide effective mechanisms for the future transformation of the existing labour market and human capital institution. Effective and high-quality measures should be developed to curb inflation and hryvnia devaluation. The authors are convinced that GDP growth in Ukraine is possible only if domestic enterprises in all sectors of the economy are active. It is believed that small, medium and large enterprises should establish close relationships with each other in order to accelerate the joint implementation of innovative projects, digitise business processes, and create a national digital ecosystem. In the future, the state, business, and research institutions should work together and coordinate their actions within the so-called "triple helix".

6. Conclusions

In light of the findings of this research, it is recommended that the government of Ukraine consider an increase in spending on scientific and technological developments as a means of achieving the objective of rapid and effective post-war reconstruction of the country's economy. It seems reasonable to posit that scientific research and S&T

developments could, in the near future, become the foundation on which large-scale reindustrialisation of production and industry could be initiated. It is evident that the introduction of new models of equipment, new production methods, technologies and production processes proposed by researchers would facilitate the renewal of outdated equipment. Furthermore, the replacement of destroyed production with new ones would enhance technical and technological processes in production and industry. It is only as a result of such changes that it will be possible to establish an innovative economy with digital entrepreneurship, achieve economic growth in the country, increase the employment of the population, slow down inflationary processes, increase exports and decrease imports, and thus protect domestic product producers.

In pursuit of the goal of restoring economic growth in Ukraine as soon as possible, it is also worth supporting SMEs in their efforts to digitise their business processes and rely on high technologies that can be produced and implemented by large enterprises. It is necessary to implement more actively the government's wishes in terms of protectionism, modernisation of existing industries, business deregulation, and development of public-private partnerships. Alongside the defence industry and the state's social function (payment of pensions, salaries, scholarships and various types of assistance), macro-financial assistance and grants should be directed to research and development to rebuild the industrial sector, transport infrastructure, electricity and communications. It is only through innovative ideas and inventions for all sectors of the economy that the desired economic growth and increase in the country's GDP can be achieved at a rapid pace. The authors believe that the government needs to develop fiscal incentives for exports and strengthen the policy of supporting investment in Ukraine with effective mechanisms.

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