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Advanced Technology Investment, Transfer, Export and Import: Determinants or Predictors of Economic Growth and Inflation Fluctuations?

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Abstract: *Investments, scientific patents, export and import of high-tech goods and services stimulate the country's technological development, contribute to economic growth, job creation, the formation of a qualified workforce, and the maintenance of social living standards of the population. At the same time, the ecosystem supporting technological innovation is largely dependent on macroeconomic stability in the country, inflationary fluctuations, etc. Based on this, the article examines systemic interrelationships between the factors of technological development (export and import of computer, information, telecommunications and other high-tech goods and services, investments in advanced research and technologies, volumes of transfer of rights to new technological developments, as well as general the level of coverage of the population by information technologies and innovativeness of the country) and macroeconomic development (gross domestic and national product, inflation rate). The research was carried out using the method of Principal component analysis, canonical analysis, panel regression modeling on the data of 11 countries with developed economies for 2011 and 2021 (World Bank and WIPO statistical databases). From 14 indicators of technological development, the 8 most relevant ones were selected using the method of Principal component analysis; by means of canonical analysis, it was found that 32.503% (in 2011) and 37.557% (in 2021) of their variation is due to changes in the studied macroeconomic indicators. On the other hand, the change in macroeconomic indicators by 46.497% (in 2011) and 38.739% (in 2021) is caused by the variation of indicators of investment, transfer, export and import of advanced technologies. Thus, macroeconomic dynamics depend much more on technological development, and not vice versa. Based on the conducted panel regression modeling, a statistically significant dependence of the inflation index on the share of the population that is Internet users and the country's place in the Global Innovation Index was revealed. GDP per capita was found to be dependent on the share of exports of high-tech goods and services, the share of exports of goods in the field of information and communication technologies, the share of the population that are Internet users, the country's place in the Global Innovation Index. State investments in research and technological development turned out to be dependent on the inflation index, the share of imports of computer, information and other services, the share of exports of goods in the field of information and communication technologies, the share of the population that are Internet users, and the country's place in the Global Innovation Index.*

Keywords: *export, import, technological development, economic growth, inflation, investments, GDP, patents, innovations.*

JEL Classification: E20, E44, O32.

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Introduction. Economically and technologically developed countries of the world have moved to a new stage of economic development, in which the priority is the large-scale implementation of scientific and technical developments and the transfer of high-performance technologies to production for the purpose of their commercialization. In the economically and technologically highly developed countries of the world, innovative activity is a key factor in the stable growth of the gross domestic product, increasing labor efficiency, increasing the competitiveness of the national economy, which provides an opportunity to maintain high social standards of living of the population. The introduction of new technologies, technical innovations, as well as the modernization of existing technologies are aimed at increasing the efficiency of production, improving the quality of products and services, increasing competitiveness on the world market, and raising the standard of living of the population (Kraus, 2019, Kuzior et al., 2023; Ober and Kochmańska, 2022). In the era of globalization, the winners in the competition are countries in which a favorable innovation environment has been created, and there are institutional and legislative incentives for technological development, creation and introduction of new products and services. Transnational corporations play an active role in stimulating technological development, cross-border transfer of innovations, trade in patents and licenses, and the spread of international scientific and research cooperation (Kazakova & Shpontak, 2021). Activation of technological development of the country depends on many factors, including the amount of physical, natural, and human capital possessed by the country, social and political stability, access to innovation markets, effectiveness of international technological cooperation, etc. (Kuzior et al., 2022a; 2022b).

According to international data, approximately 90% of the US budget, 70 to 80% of the budgets of the European Union countries and almost 100% of the budget of Japan are formed because of the commercialization of intellectual and innovative technologies. The main players in the world market of science-intensive products are the USA (39% of the market), Japan (30%), Germany (16%). Ukraine occupies less than 0.1% of this market and forms less than 10% of its national budget thanks to innovative activities (Nohornyak, 2012).

The rapid development of information technologies and the digitization of social relations, due to the impact of the Covid-19 pandemic, only accelerated the increase in investments in advanced technologies. According to the forecast of the company GlobalData, in 2024 the total volume of funds circulating within the artificial intelligence industry will be estimated at 93 billion dollars, which is 12% more than in 2023. Artificial intelligence is considered a technology that can significantly accelerate the development of robotics, quantum computing and the Internet of Things. The US and China lead the world in the number of AI patents filed from 2016 to 2022, but the industry faces a real threat from an unstable supply of advanced semiconductor chips. This actualizes the issue of resource dependence between countries in the field of high technologies and the search for new export-import opportunities.

1. Literature review

The academic community has repeatedly drawn attention to the fact that technological development and innovation processes affect the economic stability of the country. So in the studies of Arif & Eatzaz (2020), Berggren et al. (2021) and Burke (2019), the economic development of countries is considered through the prism of macroeconomic stability and technological potential. The distribution of countries by the level of development of key macroeconomic indicators was carried out in the work of Shaulska et al. (2020). Tvaronaviciene & Jurgelevicius (2020), Doronina & Karpenko (2019), who investigate the convergent effects of the influence of technological development and human capital on the economic development of a country. Dempere et al. (2023) in their work investigated the impact of innovation on three macroeconomic indicators:

GDP, self-employment and foreign direct investment, and Kregel & Savona (2020) analyzed the impact of technological innovation on the financial and money markets of countries. In the work of Wang & Xu (2021), based on OLS and WLS models, they empirically confirmed that the amount of public investment in the development of research and advanced technologies significantly affects economic growth.

Also, a significant amount of scientific research is devoted to the search for the most significant determinants of accelerating the innovative development of the country and ensuring technological progress. Thus in the work of Cirera et al. (2023) confirmed the positive impact of the fourth industrial revolution on the innovative development of the country. In their work, Chervanov & Zhilinska (2006) believe that human resources are one of the most important factors that lead to accelerated economic growth and, therefore, technological progress. The quality of human resources depends on a set of characteristics, the most important of which is their potential for innovation, the level of education, professional training, and skills. In the case of a shortage of qualified human resources, it will inhibit economic growth. In their study, Mohamed et al. (2022) note that social and political factors are factors that should play an important role in ensuring the technological development of countries. A transparent and stable policy contributes to the creation of a favorable environment for innovation and technological development. Developed infrastructure, such as transportation systems and telecommunications, ensures efficient technology development. Equally important is a high level of education, which contributes to the creation of qualified personnel who can effectively implement and develop technologies. The economic well-being of the population (total level of GDP and GDP per capita) also plays a significant role in ensuring the effectiveness of technological development. A strong and stable economy can provide the necessary resources for research and development, education, and innovation.

To assess the level of technological development, the state's readiness for innovative changes, and the impact of technological development on the country's economy, scientists suggest using various indicators. So, for example, Lazutin (2003) divides such indicators into 5 groups: 1) a group of indicators of financing of scientific and technical development (for example, the amount of funds invested in scientific and technical research; research and development costs as a percentage of GDP, etc.); 2) a group of indicators of innovative activity of enterprises (for example, the volume of investments aimed at research and development; the number of patents and licenses received by enterprises, etc.); 3) a group of indicators of the level of scientific achievements and their commercialization (for example, the number and influence of scientific publications; the number of new products or services released to the market thanks to scientific developments, etc.); 4) a group of indicators of the impact of technological development on macroeconomic stability (for example, GDP growth due to the introduction of new technologies; reduction of unemployment due to automation and more efficient production technologies, etc.); 5) a group of indicators for evaluating the country's place in the world market of science-intensive products (for example, the volume of export and import of high-tech goods and services; the country's place in the global innovation rating, etc.).

Methodology

The objects of this study are 11 countries of the world with developed economies (Great Britain, Germany, France, Italy, South Africa, USA, Canada, China, Japan, Singapore, New Zealand).

To identify changes in a ten-year retrospective, calculations were made for 2011 and 2021.

Based on data from the World Bank and WIPO, a set of panel data was formed, which included fourteen indicators of investment, transfer, export and import of advanced technologies (X1-X14) and three macroeconomic indicators (Y1-Y3):

- GDP (gross domestic product) per capita, (Y1), USD USA;
- GNI (gross national income) per capita, (Y2), USD USA;
- inflation index, (Y3), USD USA;
- share of export of computer, information and other services (X1), % of export;
- share of import of computer, information and other services (X2), % of export;
- share of export of services in the field of international telecommunications, computer data, royalties and license fees, professional and technical services (X3), % of export of commercial services;

- share of import of services in the field of international telecommunications, computer data, royalties and license fees, professional and technical services (X4), % of export of commercial services;
- share of export of high-tech goods and services, (X5), % of export;
- the share of exports of goods in the field of information and communication technologies (X6), % of exports;
- the share of imports of goods in the field of information and communication technologies (X7), % of exports;
- share of export of services in the field of information and communication technologies (X8), % of exports;
- absolute export of services in the field of information and communication technologies (X9), USD;
- the share of the population who are Internet users, (X10), %;
- scientific patents of residents, (X11), units;
- scientific patents of non-residents, (X12), units;
- country's place in the Global Innovation Index (X13), units;
- the share of state investments aimed at research and development, (X14), % of total state expenditures.

The research involves a complex combination of the following methods:

- method of Principal component analysis – for selecting the most relevant indicators among the entire set of input variables;
- canonical analysis - to identify the relationship between groups of variables;
- panel multivariate regression analysis is used to identify functional relationships between the studied variables.

Principal component analysis is a mathematical approach used to reduce the dimensionality of an input sample of metrics, which is widely used in the fields of data analysis and machine learning. The goal of this method is to transform high-dimensional data into lower-dimensional data while preserving as much of the original variance as possible.

The principal components, which are generated using Principal component analysis, represent linear combinations of the original features that capture the maximum variance in the data. The first principal component explains the largest variance, followed by the second, and so on. The variance of a principal component represents the spread or dispersion of data points along that component.

The results of Principal component analysis are based on the data of the covariance matrix, which quantifies the relationships between the different features in the data set. The diagonal elements of the covariance matrix represent the variances of individual features, while the off-diagonal elements represent the covariances. To determine the optimal number of components, it is important to determine the eigenvectors and eigenvalues of the covariance matrix. The eigenvectors represent the directions of maximum variance, and the eigenvalues indicate the amount of variance along these directions. It is necessary to sort the eigenvalues in descending order and select the first eigenvectors corresponding to the highest eigenvalues. These eigenvectors form the basis for a new feature subspace. In addition, the optimal number of components can also be determined using the stony scree plot. The contribution of the initial variables in the structure of the components is determined using factor loadings, which essentially represent the correlation coefficients of the given variables with the selected components.

Canonical analysis is a statistical method that allows you to determine the relationship between characteristics Y_0 and a set of characteristics $Y_1, \dots, Y_n$, where the multiple correlation coefficient is the key indicator, which is equal to the correlation coefficient between Y_0 and its linear simulated value (1).

$$\hat{Y} = \propto_0 + \propto_1 Y_1 + \cdots + \propto_n Y_n. \quad (1)$$

This principle allows you to determine the dependence between two sets of characteristics $Y_1, \dots, Y_n$ and $Y_{r+1}, \dots, Y_{r+n}$. Mathematical formalization is based on the calculation of random variables U_1 and V_1 together with the corresponding canonical coefficients $\propto_n$ (2-3).

$$U_1 = \propto_{10} + \propto_{11} Y_1 + \cdots + \propto_{1r} Y_r, \quad (2)$$

$$V_1 = \propto_{10} + \propto_{11} Y_{r+1} + \cdots + \propto_{1n} Y_{r+n}. \quad (3)$$

The correlation between U_1 and V_1 $R_1 = corr(U_1, V_1)$ (4) should be maximum.

$$R_{c(i)} = \frac{cov(U_i V_i)}{\sqrt{var(U_i) var(V_i)}}, \quad (4)$$

where i_{th} – canonical function;

cov – the value of the covariance between the quantities U_1 and V_1;

var – dispersion U_1 and V_1.

According to the terminology of canonical analysis, two sets of indicators are formed on the basis of the input parameters of the study: U_1, which is determined by eight indicators of capitalization of the banking system, and V_1, which is determined by five indicators of macroeconomic stability. The defined canonical parameters are characterized by the following properties:

- canonical parameters are independent linear combinations of initial indicators, distributed by groups;
- canonical variables are calculated in such a way that the corresponding canonical correlations are maximal;
- canonical variables are ordered according to the descending value of the corresponding canonical correlations;
- canonical variables from different pairs are not correlated.

Thus, canonical correlation analysis allows simultaneous analysis of the relationship between several dependent variables and many determining factors. Canonical variables (roots) represent a set of certain hidden (implicitly expressed) variables underlying the phenomenon under study. The number of canonical roots corresponds to the smallest number of variables in the group of indicators. As the ordinal number of the canonical root increases, the proportion of the studied phenomenon that is described by this root decreases.

At the last stage of the research, we will build a multivariate linear regression model of the type (5-6) with random or fixed effects. The Hausman test allows you to determine the type of model.

$$y_{it} = \alpha + X_{it}^{*}\beta + v_{it}, i = 1, \dots, N; t = 1, \dots, T, \quad (5)$$

where i – serial number of the research object;

t – research period;

α- free member;

β- vector of dimension coefficients K×1;

X_{it}^{*} - row vector of the matrix K of explanatory variables;

v_{it} - regression error.

$$v_{it} = u_i + \varepsilon_{it} \quad (6)$$

where u_i- individual effects of observations;

ε_{it}- residuals of the model.

The difference between regression models with fixed and random effects is as follows. Fixed-effects models are used when there are individual characteristics that are constant over time and need to be controlled for. Fixed effects are appropriate when these characteristics are correlated with the independent variables.

A random-effects model is constructed when there are specific effects in the study that relate to the individual characteristics of the data, uncorrelated with the independent variables, and individual-level heterogeneity must be considered.

All necessary calculations are carried out using statistical software products Statistica 12 and Stata 18.

Results

Principal component analysis method selects such indicators of investment, transfer, export and import of advanced technologies that have the most significant impact on macroeconomic indicators. Using the method of Principal component analysis, a table with eigenvalues of selected components was obtained (Table 1).

Table 1. Eigenvalues, variance, and cumulative variance of components

Component	Value	Dispersion	Cumulative variance
Component 1	4,610	0,355	0,355
Component 2	3,753	0,289	0,643
Component 3	1,455	0,112	0,844
Component 4	0,882	0,077	0,832
Component 5	0,779	0,060	0,874
Component 6	0,491	0,038	0,930
Component 7	0,336	0,026	0,948
Component 8	0,284	0,022	0,978
Component 9	0,184	0,014	0,992
Component 10	0,055	0,004	0,996
Component 11	0,044	0,003	1,000
Component 12	0,004	0,000	1,000
Component 13	0,001	0,000	1,000
Component 14	0,0001	0,000	1,000

Source: compiled by the authors.

A total of fourteen indicators of investment, transfer, export and import of advanced technologies are involved in Principal component analysis. It is necessary to determine the optimal number of components for the next stage of the study with the help of eigenvalues. The optimal number of components is the one that corresponds to an eigenvalue greater than one. In this case, these are the first three components, since they have eigenvalues greater than unity (4.610, 3.753, and 1.455, respectively). In addition, it is also worth paying attention to the fact that the cumulative variance allocated by the first three components exceeds 84%, which is quite sufficient for further research.

It is also possible to confirm or refute this decision regarding the selection of the optimal number of components for further research using the plot of the stony scree (Figure 1).

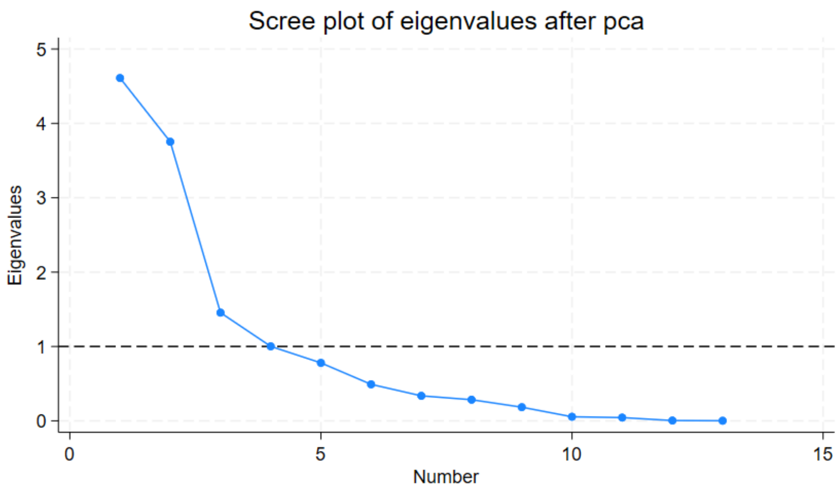

Figure 1. Graph of stony scree

Source: compiled by the authors.

The presented graph shows a curve that corresponds to the number of components and the corresponding criterion of stony scree. Moving from left to right along the curve of this graph, you need to find a place on the graph line where the change in values becomes smoother. For convenience, this place on the graph is marked with a dotted line. The number of points above this line corresponds to the optimal number of components that must be left. In this case, these are three components, which coincided with the conclusion obtained because of the calculation of the eigenvalues of the components.

So, to estimate the factor loadings, which is necessary to determine the structure of the components, we will not use the fourteen components, but only the first three. The results of the factor loadings are presented in the Table 2.

Table 2. Factor loadings of indicators

Variable	Component 1	Component 2	Component 3
X1	0,385	0,194	0,117
X2	0,420	-0,038	-0,028
X3	0,390	0,190	0,114
X4	0,423	-0,040	-0,019
X5	-0,104	0,467	0,082
X6	-0,039	0,414	-0,282
X7	-0,064	0,411	-0,276
X8	0,347	0,056	0,340
X9	0,251	0,186	0,292
X10	0,239	-0,138	-0,549
X11	-0,121	0,441	0,142
X12	-0,099	0,318	-0,022
X13	-0,251	-0,110	0,536
X14	0,113	-0,225	0,017

Source: compiled by the authors.

For the next stage of modeling, we will select those indicators of investment, transfer, export and import of advanced technologies, the factor loadings of which exceed 0.4 modulo. In this case, these are eight variables:

- the share of import of computer, information and other services (factor loading – 0.420);
- the share of import of services in the field of international telecommunications, computer data, royalties and license fees, professional and technical services (factor loading – 0.423);
- the share of export of high-tech goods and services (factor loading – 0.467);
- the share of export of goods in the field of information and communication technologies (factor loading – 0.414);
- the share of imports of goods in the field of information and communication technologies (factor loading – 0.411);
- the share of the population who are Internet users (factor loading – -0.549);
- scientific patents of residents (factor loading – 0.441);
- country's place in the Global Innovation Index (factor loading – 0.536).

Before proceeding to the canonical analysis, it is necessary to check the assumption of compliance with the normal law of the distribution of the sample of indicators involved in the study. The Shapiro-Wilk test allows you to test the hypothesis regarding the normality of the distribution of indicators by calculating the estimated value of the criterion and the corresponding confidence level of the results (p-level), the value of which must be greater than 0.05. The results of the Shapiro-Wilk test for both sets of indicators are presented in Table 3.

Table 3. Results of testing compliance with the normal law of the distribution of indicators of investment, transfer, export and import of advanced technologies and macroeconomic indicators using the Shapiro-Wilk test

Variable	Criterion Shapiro-Wilk			
	W	V	z	Prob>z
Y1	0,905	17,391	6,647	0,000

Table 3 (cont.). Results of testing compliance with the normal law of the distribution of indicators of investment, transfer, export and import of advanced technologies and macroeconomic indicators using the Shapiro-Wilk test

Variable	Criterion Shapiro-Wilk			
	W	V	z	Prob>z
Y2	0,912	16,099	6,468	0,000
Y3	0,856	26,251	7,606	0,000
X2	0,983	3,060	2,603	0,005
X4	0,982	3,217	2,720	0,003
X5	0,569	78,733	10,162	0,000
X6	0,705	53,888	9,280	0,000
X7	0,818	33,328	8,161	0,000
X10	0,808	35,048	8,278	0,000
X11	0,808	35,048	8,278	0,000
X13	0,398	109,860	10,937	0,000

Source: compiled by the authors.

Considering the results of the Shapiro-Wilk test and the corresponding confidence level of the results (*p*-level), all indicators do not correspond to the normal distribution law. However, the technological potential of canonical analysis allows us to continue research despite the current situation.

Given the terminology of canonical analysis, it is necessary to determine the lists of variables that will be included in *U* and *V*. Let *U* contain indicators of investment, transfer, export and import of advanced technologies, and *V* - macroeconomic indicators.

The next step in the canonical analysis is to study the level of correlation between the studied variables, considering their redistribution between groups U and V using correlation analysis. This will test assumptions about data redundancy. The results of the correlation analysis are presented in Figure 2.

Correlations (Spreadsheet1)

variable	X2	X4	X5	X6	X7	X10	X11	X13	Y1	Y2	Y3
X2	1,000	0,998	-0,288	-0,066	-0,114	0,425	-0,324	-0,418	0,251	0,039	-0,197
X4	0,998	1,000	-0,285	-0,063	-0,121	0,427	-0,325	-0,411	0,260	0,044	-0,204
X5	-0,288	-0,285	1,000	0,656	0,621	-0,389	0,919	-0,043	-0,388	-0,354	-0,010
X6	-0,066	-0,063	0,656	1,000	0,912	-0,137	0,529	-0,202	-0,211	-0,102	-0,044
X7	-0,114	-0,121	0,621	0,912	1,000	-0,155	0,526	-0,160	-0,234	-0,049	-0,002
X10	0,425	0,427	-0,389	-0,137	-0,155	1,000	-0,383	-0,638	0,601	0,564	-0,130
X11	-0,324	-0,325	0,919	0,529	0,526	-0,383	1,000	0,027	-0,379	-0,353	-0,022
X13	-0,418	-0,411	-0,043	-0,202	-0,160	-0,638	0,027	1,000	-0,497	-0,385	0,320
Y1	0,251	0,260	-0,388	-0,211	-0,234	0,601	-0,379	-0,497	1,000	0,609	-0,134
Y2	0,039	0,044	-0,354	-0,102	-0,049	0,564	-0,353	-0,385	0,609	1,000	-0,006
Y3	-0,197	-0,204	-0,010	-0,044	-0,002	-0,130	-0,022	0,320	-0,134	-0,006	1,000

Figure 2. Correlation matrix between indicators of innovative development and macroeconomic indicators

Source: compiled by the authors.

Based on the results of the correlation analysis, it was found that there is a high correlation (above 0.7) between several indicators within the studied groups:

- between the share of import of computer, information and other services and the share of import of services in the field of international telecommunications, computer data, royalties and license fees, professional and technical services (0.998);
- between the share of export of high-tech goods and services and the number of scientific patents of residents (0.919);
- between the share of exports of goods in the field of information and communication technologies and the share of imports of goods in the field of information and communication technologies (0.912).

Thus, the following variables will not be involved in the canonical analysis and construction of the regression model:

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- the share of import of services in the field of international telecommunications, computer data, royalties and license fees, professional and technical services;
- the share of imports of goods in the field of information and communication technologies;
- the number of scientific patents of residents.

Canonical analysis will be conducted for the statistical data of the studied countries for 2011 and 2021 to identify possible structural changes between indicators of investment, transfer, export and import of advanced technologies and macroeconomic indicators. The first results of the canonical analysis for 2011 and 2021 are presented in Figure 3 and 4.

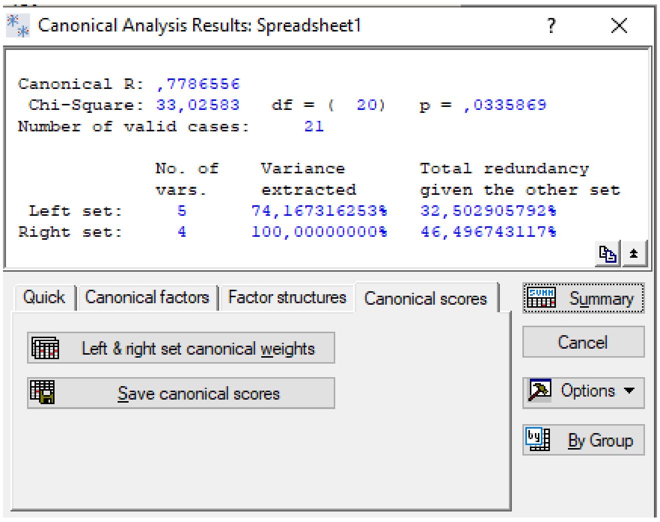

Figure 3. Results of canonical analysis for data as of 2011

Source: compiled by the authors.

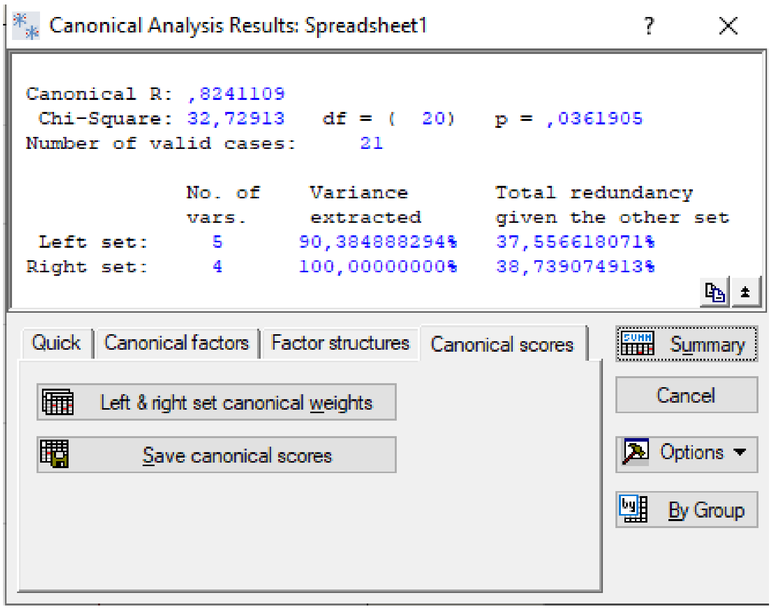

Figure 4. Canonical analysis results for data as of 2021

Source: compiled by the authors.

It is worth noting that in 2011, 74.167%, and in 2021, 90.385% of indicators of investment, transfer, export and import of advanced technologies are included in the analysis (Variance extracted equals 74.167% and 90.385%, respectively). Macroeconomic indicators in their entirety (100%) participate in the analysis (Variance extracted equals 100%) in 2011 and 2021. According to the results of Total redundancy presented in Figures 3 and 4, 32.503% and 37.557% of the variation of the researched indicators of investment, transfer, export and import of advanced technologies in 2011 and 2021 is due to the change of the studied macroeconomic indicators. On the other hand, the change in the country's macroeconomic indicators by 46.497% (2011) and 38.739% (2021) is due to the variation in indicators of investment, transfer, export and import of advanced technologies. As we can see, macroeconomic indicators are determined to a greater extent by indicators of investment, transfer, export and import of advanced technologies, and not vice versa. This provides a basis for determining the dependent and independent variables when performing regression modeling.

The values of *The Chi-Square* indicators and p ($p < 0.05$) for both years of analysis confirm the statistical significance of the obtained results. The canonical correlation coefficient R_2 for both models is greater than 0.7, which indicates the high quality of the resulting dependencies and the close relationship between indicators of investment, transfer, export and import of advanced technologies and macroeconomic stability.

To find the optimal number of canonical roots, it is necessary to analyze statistical indicators: The Chi-Square indicators, the canonical coefficient of determination R_2 and the probability level p (Figures 5, 6).

	Chi-Square Tests with Successive Roots Removed (Spreadsheet1)					
Root Removed	Canonicl R	Canonicl R-sqr.	Chi-sqr.	df	p	Lambda Prime
0	0,778656	0,606305	33,02583	20	0,033587	0,110613
1	0,763120	0,582352	19,04317	12	0,087556	0,280960
2	0,553915	0,306822	5,94644	6	0,429237	0,672718
3	0,171805	0,029517	0,44942	2	0,798750	0,970483

Figure 5. Table with resulting values of canonical roots as of 2011

Source: compiled by the authors.

	Chi-Square Tests with Successive Roots Removed (Spreadsheet1)					
Root Removed	**Canonicl R**	Canonicl R-sqr.	Chi-sqr.	df	p	Lambda Prime
0	0,824111	0,679159	32,72913	20	0,036191	0,112822
1	0,784354	0,615211	15,67700	12	0,206550	0,351645
2	0,247774	0,061392	1,35110	6	0,968762	0,913864
3	0,162365	0,026362	0,40074	2	0,818428	0,973638

Figure 6. Table with resulting values of canonical roots as of 2021

Source: compiled by the authors.

Having analyzed the criterion of significance *p* ($p < 0.05$) (Figures. 5 and 6), we can conclude that for further analysis of the results it is necessary to focus on the first canonical roots for both years of the study, since the first canonical roots (Root 0) in both cases explain more than 77% of the variation of the studied interaction between indicators.

The next step of the canonical analysis is the study of the factor loadings within the canonical roots for the sets *U* (left set) and *V* (right set) for 2011 and 2021 (Figures 7-10).

	Factor Structure, left set (Spreadsheet1)		
Variable	Root 1	Root 2	Root 3
X2	0,461545	0,521768	-0,028760
X5	-0,535199	0,318791	-0,062564
X6	-0,531644	-0,053057	-0,388096
X10	0,916829	-0,277707	-0,208376
X13	-0,630704	0,274258	-0,099023

Figure 7. Factor loadings of the canonical roots of the first list of indicators in 2011

Source: compiled by the authors.

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Variable	Factor Structure, right set (Spreadsheet1)		
	Root 1	Root 2	Root 3
Y1	0,620096	-0,612945	-0,385648
Y2	-0,829755	-0,510058	-0,206676
Y3	0,318988	0,009395	-0,813478

Figure 8. Factor loadings of the canonical roots of the second list of indicators in 2011

Source: compiled by the authors.

Variable	Factor Structure, left set (Spreadsheet1)		
	Root 1	Root 2	Root 3
X2	0,560134	-0,481034	-0,441014
X5	-0,453972	-0,425062	0,215629
X6	-0,076535	-0,256290	0,711753
X10	0,886651	0,384144	0,013145
X13	-0,742070	0,498483	-0,248587

Figure 9. Factor loadings of the canonical roots of the first list of indicators in 2021

Source: compiled by the authors.

Variable	Factor Structure, right set (Spreadsheet1)		
	Root 1	Root 2	Root 3
Y1	0,624000	0,451501	0,633014
Y2	-0,108939	0,767700	0,032101
Y3	0,118836	0,610481	0,380256

Figure 10. Factor loadings of the canonical roots of the second list of indicators in 2021

Source: compiled by the authors.

The obtained factor loadings of the investigated indicators within the first canonical root allow us to draw the following conclusions:

- in 2011 and 2021, the largest correlation exists between the share of the population who are Internet users (factor loading – 0.917 and 0.887, respectively) and the global innovation index (factor loading – -0.631 and -0.742, respectively);
- in 2011, GNI has the largest correlation with the entire set of macroeconomic indicators (factor loading - 0.829), in 2021 - GDP (factor loading - 0.624).

To determine the coefficients of canonical regression equations, it is necessary to determine canonical weights (the contribution of each indicator to the formation of canonical variables (roots)). Canonical weights for both samples as of 2011 and 2021 are presented in Figures 11-14.

Variable	Canonical Weights, left set (Spreadsheet1		
	Root 1	Root 2	Root 3
X2	0,230850	0,979705	-0,148160
X5	0,249495	1,008533	0,004020
X6	-0,511445	-0,596695	-1,144100
X10	0,837100	0,295886	-1,806280
X13	0,019097	0,794222	-1,773140

Figure 11. Canonical weights of indicators of the first list in 2011

Source: compiled by the authors.

Variable	Canonical Weights, right set (Spreadshee		
	Root 1	Root 2	Root 3
Y1	0,069000	-0,336922	1,170830
Y2	0,319923	0,845581	-0,325860
Y3	-0,639189	0,580750	0,390470

Figure 12. Canonical weights of indicators of the second list in 2011

Source: compiled by the authors.

Variable	Canonical Weights, left set (Spreadsheet Root 1	Root 2	Root 3
X2	0,034940	-0,527808	-0,834490
X5	-0,312476	-0,019096	-1,101910
X6	-0,105705	-0,085000	0,959720
X10	0,423360	0,923320	-0,609020
X13	-0,613300	0,725261	-0,782440

Figure 13. Canonical weights of indicators of the first list in 2021

Source: compiled by the authors.

Variable	Canonical Weights, right set (Spreadshee Root 1	Root 2	Root 3
Y1	-0,929998	-0,336922	1,170830
Y2	0,717820	0,845581	-0,325860
Y3	-0,214388	0,580750	0,390470

Figure 14. Canonical weights of indicators of the second list in 2021

Source: compiled by the authors.

The canonical regression equations constructed on the basis of the received canonical weights from the first canonical root Root 1 have the following form:

$$U_{2011} = 0{,}231X2 + 0{,}249X5 - 0{,}511X6 + 0{,}834X10 + +0{,}019X13 \quad (7)$$

$$V_{2011} = 0{,}069Y1 + 0{,}320Y2 - 0{,}639Y3 \quad (8)$$

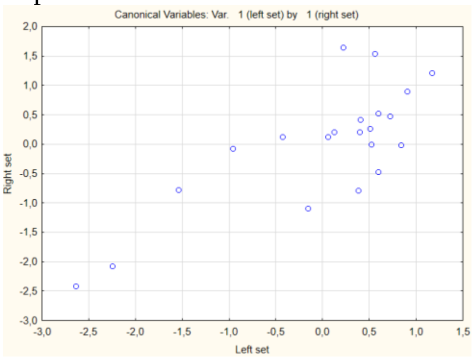
$$U_{2021} = 0{,}035X2 - 0{,}312X5 - 0{,}106X6 + 0{,}423X10 - 0{,}613X13 \quad (9)$$

$$V_{2021} = -0{,}929Y1 + 0{,}718Y2 - 0{,}214Y3 \quad (10)$$

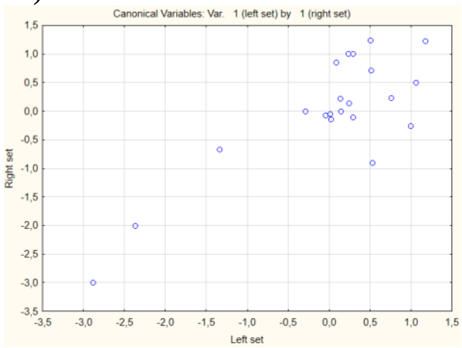
The received canonical weights make it possible to identify the following functional dependencies:

- in 2011, the greatest influence on the technological development of the studied countries was exerted by such indicators as the share of exports of goods in the field of information and communication technologies and the share of the population that are Internet users. With an increase in the share of exports of goods in the field of information and communication technologies by one unit, the aggregate level of indicators of investment, transfer, export and import of advanced technologies will decrease by 0.511 units. With an increase in the share of the population who are Internet users, the aggregate level of indicators of investment, transfer, export and import of advanced technologies will increase by 0.834 units;
- in 2021, the greatest influence on the technological development of the studied countries was exerted by such indicators as: the share of the population that are Internet users, and the country's place in the Global Innovation Index. With an increase in the share of the population who are Internet users, the aggregate level of investment, transfer, export and import of advanced technologies will increase by 0.423 units per unit. As a country's ranking in the Global Innovation Index increases by one unit, the aggregate level of indicators of investment, transfer, export and import of advanced technologies will decrease by 0.613 units;
- in 2011, the inflation index exerted the greatest influence on the macroeconomic development of the studied countries. With its increase by one unit, the aggregate level of macroeconomic indicators will decrease by 0.639 units;
- in 2021, the greatest influence on the macroeconomic development of the studied countries was exerted by GNI per capita. With its increase by one unit, the aggregate level of macroeconomic indicators will increase by 0.718 units.

The final stage of the canonical analysis is the construction of a scatter diagram for the first canonical roots of both groups of research indicators in 2011 and 2021 (Figure 15).



2011



2021

Figure 15. Scatter diagram of indicators of the first and second lists (Left and Right set) in 2011 and 2021

Source: compiled by the authors.

As can be seen from the presented scatter diagrams, the presence of a close functional relationship between indicators of technological development and macroeconomic stability is confirmed.

Regression modeling for panel data begins by determining the type of model with fixed or random effects. For this, it is necessary to use the Hausman test. If the p level for the calculated value of the Hausman test is less than 0.05, then it is worth building a model with fixed effects, otherwise - with random effects.

Based on the results of the canonical analysis (macroeconomic indicators largely depend on indicators of investment, transfer, export and import of advanced technologies) and the purpose of this study, we will build four panel regression models.

Macroeconomic indicators will act as the dependent variable *Y*:

GDP (gross domestic product) per capita,

- GNI (gross national income) per capita,
- inflation index,
- the share of state investments aimed at research and development.

The role of independent variables for the first three regression models will be five indicators of investment, transfer, export and import of advanced technologies, selected at the stage of correlation analysis within the canonical analysis:

- share of import of computer, information, and other services,
- share of export of high-tech goods and services,
- the share of exports of goods in the field of information and communication technologies,
- the share of the population who are Internet users,
- the country's place in the Global Innovation Index

The construction of panel regression equations was carried out using the software tool Stata 18. Before starting any calculations in the program, it is necessary to regulate in the appropriate settings of the program that all further calculations will take place for panel data (*Statistics > Longitudinal/ panel data > Setup and utilities > Declare dataset to be panel data*).

The results of the Hausman test for the first regression model with the dependent variable “inflation index” are presented in Figure16.

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference       Std. err.
-------------+----------------------------------------------------------------
         X 2 |   -.004488    -.0105926        .0061046        .0196195
         X 5 |  -.0017803     .0008349       -.0026152        .0046443
         X 6 |  -.1560314     .0045639       -.1605953        .0958126
        X 10 |   .0581325      .037092        .0210405        .0183784
        X 13 |   .0508216     .0690207       -.0181991        .0339193
------------------------------------------------------------------------------
                           b = Consistent under H0 and Ha; obtained from xtreg.
            B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   5.96
Prob > chi2 = 0.3104
```

Figure 16. Results of the Hausman test for the first regression model with the inflation index as the dependent variable

Source: compiled by the authors.

As we can see, the value of p for the obtained Hausman test is equal to 0.3104, which is significantly higher than 0.05 and indicates that to describe the functional relationships between the dependent variable "inflation index" and the five indicators of investment, transfer, export and import of advanced technologies, it is necessary to build a panel regression model with random effects.

The software results of building a multifactor regression model are presented in Figure 17.

Given the obtained results of regression modeling parameters, we will construct the corresponding regression equation (11).

$$Y3 = -1{,}722 \; - 0{,}01X2 + 0{,}0008X5 + 0{,}004X6 + +0{,}037X10 + 0{,}069X13 \qquad (11)$$

```
Random-effects GLS regression                   Number of obs     =        252
Group variable: id                              Number of groups  =         21

R-squared:                                      Obs per group:
     Within  = 0.0306                                         min =         12
     Between = 0.4707                                         avg =       12.0
     Overall = 0.1225                                         max =         12

                                                Wald chi2(5)      =      22.54
````(u_i, X) = 0 (assumed)                       Prob > chi2       =     0.0004

          Y3 | Coefficient Std. err.   z   P>|z| [95% conf. interval]
-------------+--
         X 2 | -.0105926   .0119685   -0.89   0.376   -.0340505   .0128652
         X 5 | .0008349   .001485   0.56   0.574   -.0020757   .0037455
         X 6 | .0045639   .024473   0.19   0.852   -.0434023   .0525302
        X 10 | .037092   .0162163   2.29   0.022   .0053087   .0688753
        X 13 | .0690207   .0163884   4.21   0.000   .0369   .1011414
       _cons | -1.7224   1.635058   -1.05   0.292   -4.927056   1.482255
-------------+--
     sigma_u | .50670096
     sigma_e | 1.8418159
         rho | .07036   (fraction of variance due to u_i)

```

**Figure 17. Results of building the first regression model with random effects**

Source: compiled by the authors.

The value of p for the Wald test is 0.0004, which is less than 0.05 and indicates the statistical significance of the model. However, after analyzing the probability of p for the corresponding criteria z in the resulting table of regression parameters, only two obtained values of regression parameters indicate a statistically significant effect on the dependent variable - the share of the population that is Internet users and the country's place in the Global Innovation Index. Therefore, we interpret the results specifically for these two indicators:

➢ with an increase in the share of the population who are Internet users by 1%, the inflation index will increase by 0.037%;

➢ with an increase in the country's place in the Global Innovation Index by one unit, the inflation index will increase by 0.069%.
```

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In the second regression model, the role of the dependent variable is performed by GNI (gross national income) per capita. Similarly, to the previous regression model, it is first necessary to determine its type using the Hausman test. The results of this test for the second model are presented in Figure 18.

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference       Std. err.
-------------+----------------------------------------------------------------
         X 2 |    .2996368    -.0049411        .3045779        .3636926
         X 5 |   -.0052336    -.0127669        .0075333        .0819534
         X 6 |    -.144864     .2220748       -.3669389        1.682938
        X 10 |   -.1942972     .1198374       -.3141346        .3442658
        X 13 |   -.1579914    -.0450152       -.1129762        .6084049
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtreg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   1.32
Prob > chi2 = 0.9327
```

Figure 18. Results of the Hausman test for the second regression model with the dependent variable GNI (gross national income) per capita

Source: compiled by the authors.

As we can see, the value of p for the obtained Hausman test is equal to 0.9327, which is significantly higher than 0.05 and indicates that to describe the functional relationships between the dependent variable GNI (gross national income) and the five indicators of investment, transfer, export and import of advanced technologies, it is necessary to build a panel regression model with random effects.

The software results of building a multifactor regression model are presented in fig. 19.

Considering the obtained results of regression modeling parameters, we will construct the corresponding regression equation (12).

$$Y2 = -4{,}038 - 0{,}005X2 - 0{,}013X5 + 0{,}222X6 + +0{,}119X10 - 0{,}045X13 \quad (12)$$

```
. xtreg econ5 tech2 tech5 tech6 tech10 tech13,re

Random-effects GLS regression                   Number of obs     =        252
Group variable: id                              Number of groups  =         21

R-squared:                                      Obs per group:
     Within  = 0.0001                                         min =         12
     Between = 0.1369                                         avg =       12.0
     Overall = 0.0080                                         max =         12

                                                Wald chi2(5)      =       1.98
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.8515

------------------------------------------------------------------------------
          Y2 | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
          X2 |  -.0049411   .1611285    -0.03   0.976    -.3207472     .310865
          X5 |  -.0127669   .0201615    -0.63   0.527    -.0522828     .026749
          X6 |   .2220748   .3121247     0.71   0.477    -.3896783    .8338279
         X10 |   .1198374   .2479024     0.48   0.629    -.3660423    .6057172
         X13 |  -.0450152   .2345082    -0.19   0.848    -.5046429    .4146124
       _cons |  -4.038361   25.77502    -0.16   0.875    -54.55648    46.47976
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  31.879478
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Figure 19. Results of building the second regression model with random effects

Source: compiled by the authors.

The *p* value for the Wald test for this model is 0.8515, which is greater than 0.05 and indicates the statistical insignificance of the model. Therefore, there is no need to interpret the obtained results of the regression equation.

In the third regression model, the role of the dependent variable is performed by GDP (gross domestic product) per capita. Similarly, to the previous regression model, it is first necessary to determine its type using the Hausman test. The results of this test for the third model are presented in Figure 20.

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference       Std. err.
-------------+----------------------------------------------------------------
          x2 |   -.0110214    -.0117693        .0007478               .
          x5 |    .0032102     .0003526        .0028576        .0006039
          x6 |    .0819631     .0381954        .0437677        .0132562
         x10 |    .0329082     .0415231       -.0086149        .0010785
         x13 |    .0503819     .0314594        .0189225         .002595
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtreg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  24.79
Prob > chi2 = 0.0002
(V_b-V_B is not positive definite)
```

Figure 20 Results of the Hausman test for the third regression model with the dependent variable GDP (gross domestic product) per capita

Source: compiled by the authors.

As we can see, the p value for the obtained Hausman test is 0.0002, which is significantly less than 0.05 and indicates that to describe the functional relationships between the dependent variable GDP (gross domestic product) per capita and the five indicators investment, transfer, export and import of advanced technologies, it is necessary to build a panel regression model with fixed effects. The software results of building a multifactor regression model are presented in Figure 21. Given the obtained results of the regression modeling parameters, we will construct the corresponding regression equation (13).

$$Y1 = 1{,}109 - 0{,}011X2 + 0{,}003X5 + 0{,}082X6 + +0{,}033X10 + 0{,}050X13 \quad (13)$$

```
Fixed-effects (within) regression               Number of obs     =        252
Group variable: id                              Number of groups  =         21

R-squared:                                      Obs per group:
     Within  = 0.2125                                         min =         12
     Between = 0.2385                                         avg =       12.0
     Overall = 0.1848                                         max =         12

                                                F(5, 226)         =      12.20
corr(u_i, Xb) = -0.7058                         Prob > F          =     0.0000

------------------------------------------------------------------------------
          Y1 | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
          X2 |  -.0110214   .0067667    -1.63   0.105    -.0243553    .0023124
          X5 |   .0032102   .0014357     2.24   0.026     .0003812    .0060392
          X6 |   .0819631   .0291163     2.82   0.005     .0245889    .1393373
         X10 |   .0329082   .0072166     4.56   0.000     .0186879    .0471286
         X13 |   .0503819   .0110917     4.54   0.000     .0285256    .0722382
       _cons |   1.109411   .5585256     1.99   0.048     .0088275    2.209995
-------------+----------------------------------------------------------------
     sigma_u |  3.0157373
     sigma_e |  .54229555
         rho |  .96867695   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(20, 226) = 119.52                   Prob > F = 0.0000
```

Figure 21. Results of building the third regression model with fixed effects

Source: compiled by the authors.

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The value of p for the Wald test is 0.0000, which is less than 0.05 and indicates the statistical significance of the model as a whole. Having analyzed the probability of p for the corresponding criteria z in the resulting table of regression parameters, it can be concluded that all values of regression parameters, except for the first one, the share of imports of computer, information, and other services, indicate a statistically significant effect on the dependent variable. Therefore, we interpret the results of the obtained parameters:

➢ with an increase in the share of export of high-tech goods and services by USD 1. GDP per capita will increase by $0.003;

➢ with an increase in the share of exports of goods in the field of information and communication technologies by 1%, GDP per capita will increase by 0.082 dollars;

➢ with an increase in the share of the population who are Internet users, by 1% GDP per capita will increase by 0.033 dollars;

➢ with an increase in the country's place in the Global Innovation Index, per unit of GDP per capita will increase by $0.050.

In the fourth regression model, the role of the dependent variable will be performed by the share of state investments aimed at research and development, and the role of independent five indicators of investment, transfer, export and import of advanced technologies (the share of import of computer, information and other services, the share of export of high-tech goods and services, the share of exports of goods in the field of information and communication technologies, the share of the population that are Internet users, the country's place in the Global Innovation Index)) and three macroeconomic indicators (GDP (gross domestic product) per capita, GNI (gross national income) per capita, inflation index).

Using the Hausman test, we determine the type of panel regression model. The results of the check are presented in the following Figure 22.

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference       Std. err.
-------------+----------------------------------------------------------------
         Y 3 |    .0488435     .0473482       .0014953        .0007225
         Y 2 |    .0002882     .0002617       .0000265               .
         Y 1 |   -.0111402    -.0077002        -.00344        .0097768
         X 2 |     .007246     .0071577       .0000884        .0003045
         X 5 |    .0010593     .0006992       .0003601        .0002537
         X 6 |    .0502239     .0407068       .0095171         .005638
        X 10 |    .0050236     .0062666       -.001243         .000511
        X 13 |   -.0159468    -.0180082       .0020614        .0015776
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtreg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  14.54
Prob > chi2 = 0.0688
(V_b-V_B is not positive definite)
```

Figure 22. Results of the Hausman test for the fourth regression model with the dependent variable share of public investments aimed at research and development

Source: compiled by the authors.

As we can see, the value of p for the obtained Hausman test is greater than 0.05 and indicates that for the description of the functional relationships between the dependent variable the share of public investments aimed at research and development and indicators of investment, transfer, export and import of advanced technologies and macroeconomic indicators, it is necessary to build a panel regression model with random effects.

The software results of building a multifactor regression model are presented in Figure 23.

```
Random-effects GLS regression                   Number of obs     =        252
Group variable: id                              Number of groups  =         21

R-squared:                                      Obs per group:
     Within  = 0.3987                                         min =         12
     Between = 0.2379                                         avg =       12.0
     Overall = 0.2480                                         max =         12

                                                Wald chi2(8)      =     152.52
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000
```

X 14	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Y 3	.0473482	.0075763	6.25	0.000	.0324989	.0621975
Y 2	.0002617	.0004241	0.62	0.537	-.0005696	.001093
Y 1	-.0077002	.0238847	-0.32	0.747	-.0545133	.039113
X2	.0071577	.0024792	2.89	0.004	.0022986	.0120168
X5	.0006992	.0004695	1.49	0.136	-.0002209	.0016193
X6	.0407068	.0094642	4.30	0.000	.0221573	.0592562
X10	.0062666	.0027228	2.30	0.021	.0009301	.0116032
X13	-.0180082	.0039451	-4.56	0.000	-.0257405	-.0102759
_cons	1.290995	.2645495	4.88	0.000	.7724871	1.809502
sigma_u	.73604341					
sigma_e	.19881279					
rho	.93200164	(fraction of variance due to u_i)				

Figure 23. Results of building the fourth regression model with fixed effects

Source: compiled by the authors.

Considering the obtained results of regression modeling parameters, we will construct the corresponding regression equation (14).

$$X14 = 1{,}290 + 0{,}0472Y3 + 0{,}0003Y2 - 0{,}008Y1 + 0{,}007X2 + 0{,}0007X5 + 0{,}04X6 + 0{,}006X10 - -0{,}018X13 \quad (14)$$

The value of p for the Wald test is 0.0000, which is less than 0.05 and indicates the statistical significance of the model as a whole. After analyzing the probability of p for the corresponding criteria z in the resulting table of regression parameters, many values of regression parameters, in addition to GNI (gross national income) per capita, inflation index and shares of exports of high-tech goods and services, indicate a statistically significant effect on the dependent variable. Therefore, we interpret the results of the obtained parameters:

- with an increase in the inflation index by 1%, the share of state investments aimed at research and development will increase by 0.0003%;
- with an increase in the share of imports of computer, information and other services by 1%, the share of state investments aimed at research and development will increase by 0.007%;
- with an increase in the share of exports of goods in the field of information and communication technologies by 1%, the share of state investments aimed at research and development will increase by 0.04%;
- with an increase in the share of the population who are Internet users by 1%, the share of state investments aimed at research and development will increase by 0.006%;
- with an increase in the global innovation index by one unit, the share of public investments aimed at research and development will decrease by 0.018%.

Conclusions

Using the method of Principal component analysis, the eight most relevant indicators of investment, transfer, export and import of advanced technologies were selected, which are factor variables in the process of canonical analysis and panel regression modeling.

During the canonical analysis, it was found that 32.503% and 37.557% of the variation of the studied indicators of investment, transfer, export and import of advanced technologies in 2011 and 2021 is due to the change of the studied macroeconomic indicators. On the other hand, the change in macroeconomic indicators by 46.497% (year 2011) and 38.739% (year 2021) is due to the variation of indicators of investment, transfer, export and import of advanced technologies. Thus, macroeconomic dynamics depend much more on technological development, and not vice versa.

Based on the conducted panel regression modeling, it was found that two variables exert a statistically significant influence on the inflation index:

➢ with an increase in the share of the population who are Internet users by 1%, the inflation index will increase by 0.037%;

➢ with an increase in the country's place in the Global Innovation Index by one unit, the inflation index will increase by 0.069%.

GDP per capita is determined by the influence of four indicators:

➢ with an increase in the share of export of high-tech goods and services by USD 1. GDP per capita will increase by $0.003;

➢ with an increase in the share of exports of goods in the field of information and communication technologies by 1%, GDP per capita will increase by 0.082 dollars;

➢ with an increase in the share of the population who are Internet users by 1%, GDP per capita will increase by $0.033;

➢ with an increase in the country's place in the Global Innovation Index, per unit of GDP per capita will increase by $0.050.

Five variables exert a statistically significant influence on the share of state investments aimed at research and development:

➢ with an increase in the inflation index by 1%, the share of state investments aimed at research and development will increase by 0.0003%;

➢ with an increase in the share of imports of computer, information and other services by 1%, the share of state investments aimed at research and development will increase by 0.007%;

➢ with an increase in the share of exports of goods in the field of information and communication technologies by 1%, the share of state investments aimed at research and development will increase by 0.04%;

➢ with an increase in the share of the population who are Internet users by 1%, the share of state investments aimed at research and development will increase by 0.006%;

➢ with an increase in the country's place in the Global Innovation Index by one unit, the share of public investments aimed at research and development will decrease by 0.018%.

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