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5 INFORMATION AND ANALYTICAL SUPPORT FOR THE DEVELOPMENT OF A STRATEGY FOR THE DEVELOPMENT OF THE INNOVATIVE INFRASTRUCTURE OF UKRAINE

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ABSTRACT

The analysis of the process of making managerial decisions was carried out; its varieties are determined depending on the type of managerial decisions; the types used in the process of making managerial decisions are determined. The features and advantages of Data-driven decision-making over Highest Paid Person's Opinion are determined. The author's approach to understanding the concept of «information and analytical support of managerial decisions» is proposed, the types of information and analytical support of managerial decisions and the methods used for its formation are determined. The analysis of the features of the innovative development of the countries of the world is carried out. Based on the cluster analysis, three groups of countries were identified (countries that are leaders in innovative development, countries that are moderate innovators, countries that are modest innovators), which are characterized by similar parameters and results of innovative development. Identified and ranked (based on the results of the correlation analysis) the main factors that determine the features of the innovative development of the leading countries of innovative development.

Based on the method of the main components, it has been established that the country's innovative development is more not deterministic, but a controlled process, the main objects of which are the architecture of the innovation infrastructure, the volume of public expenditures on R&D. The analysis of the state and peculiarities of the development of the innovative infrastructure of Ukraine is carried out.

The strategic directions for the development of the innovative infrastructure of Ukraine (development of the institutional environment for the development of the innovative infrastructure, reconfiguration and diversification of the functional components of the innovative infrastructure, increasing the competitiveness of the structural elements of the functional components of the innovative infrastructure) have been determined.

On the basis of correlation-regression analysis, calculation of partial coefficients of elasticity, the potentially most effective variant of reconfiguration of the functional components of the innovation infrastructure has been established.

KEYWORDS

Managerial decision, decision-making process, data, data-driven decision-making, Highest Paid Person's Opinion, data-driven decision making capability, information and analytical support of managerial decisions, innovative development, innovative infrastructure, strategy for the development of the innovative infrastructure of Ukraine.

5.1 THE THEORETICAL BASIS FOR THE FORMATION OF INFORMATION AND ANALYTICAL SUPPORT FOR MANAGERIAL DECISIONS

The most important result of management activities of all types and levels are managerial decisions. There are six types of managerial decisions, depending on their focus:

1. Policy and Implementation Decisions.
2. Tactical and Strategic Decisions.
3. Programmed and Non-programmed Decision.
4. Basic and Routine Decisions.
5. Organizational and Personal Decisions.
6. Reactive and Planned Decisions [1].

Management activity associated with making a managerial decision is a decision-making process (DMP). Depending on the type of managerial decision generated, the types of DMP are distinguished (**Fig. 5.1**).

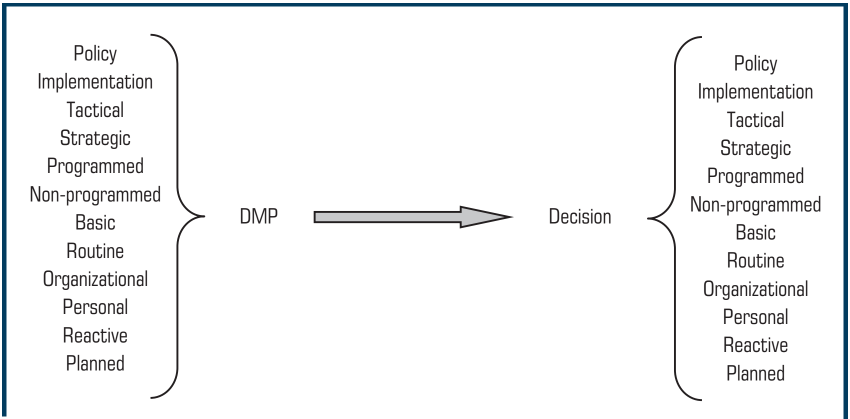


Fig. 5.1 Types of managerial decisions and varieties of DMP
Source: compiled by the author based on data [1–20]

Each type of DMP has specific features that are determined by the type of managerial decision made by its object, subject and subject matter of it.

From the standpoint of economic theory and the rational model of decision making, any type of DMP is a multistage process that includes the following stages:

1. Formulating a goal(s).
2. Identifying the criteria for making the decision.
3. Identifying alternatives.
4. Performing an analysis.

5. Making a final decision [1].

However, as practice shows, in reality, DMP rarely fully consists in rational model of decision making, and, as a consequence, decisions are made in conditions of limited rationality.

There are the following most common non-rational decision making models:

1. Bounded rationality model (the rationality of the decision is limited by such factors as the cognitive capacity of managers and time constraints, under such conditions managers seek alternatives only until they find one that looks satisfactory, rather than seeking the optimal decision).

2. Incremental model (the rationality of the solution is limited by a number of factors, including the reluctance of managers to solve a certain problem, the desire to reduce it to an acceptable level).

3. Garbage-can model (the rationality of the solution is limited by the lack of strategic vision, understanding of the problem, interests, and the practice of those who were involved in solving it).

4. Negotiated Order (the rationality of the decision is limited by the lack of evidence, facts, data, compromise, it is determined in terms of involving various groups of people in the decision-making process) [1].

Understanding that DMP rarely fully consists in rational model of decision making, the presence of a significant number of non-rational decision making models does not mean that the management process does not need to strive to rationalize the decision made, but indicates that certain difficulties arising from ensuring this. A key element in the rationalization of DMP is Situation Awareness or situation assessment [13]. A Situation Awareness or Situation Assessment cannot be carried out without relevant information.

The concept of «information» is not clearly defined today. However, most often it means data, facts about a situation, object of research, etc. [21, 22].

Most often, there are 6 types of information, data:

1. Quantitative data (information that seems to be the easiest to explain).

2. Qualitative data (information that consist of words, pictures, and symbols, not numbers, can't be expressed as a number and can't be measured).

3. Nominal data (information that is used just for labeling variables, without any type of quantitative value).

4. Ordinal data (information that shows where a number is in order).

5. Discrete data (information that involves only integers).

6. Continuous data (information that could be meaningfully divided into finer levels. It can be measured on a scale or continuum and can have almost any numeric value) [23].

In addition, at the present stage of development, the 7th type of data is distinguished – Big Data, which is digitized, heterogeneous data characterized by specific properties (Volume (starting from petabytes, which is equivalent to 10 ^ 15 bytes); Velocity (as the rate of receipt, accumulation data and the speed of their processing in order to obtain final results); Variety; Veracity; Value (according to IBS estimates, only 1.5 % of the accumulated data arrays have informational value); Variability; Volatility; Vulnerability; Validity; Visualization), which cannot be processed by traditional methods [24].

Data-driven decision-making (DDDM) or evidence-based decision making [4, 8, 9].

As modern management practice shows, DDDM is an alternative to HiPPO (Highest Paid Person's Opinion), that is, a decision that is made based on the opinion of a manager, an intuitive decision. As Charles Yoe notes, HiPPO or «... have relied on such things as precedent, trial and error, expert opinion, professional judgment, compromise, safety assessment standards, precaution, inspection, zero tolerance» [14].

DDDM results are more objective, transparent, reasonable, successful [3], less risky compared to HiPPO. Despite the significant advantages of DDDM over HiPPO, «The Harvard Business Review found that while 80 % of survey respondents rely on data in their roles and 73 % rely on data to make decisions, 84 % still said managerial judgment is a factor when making key decisions» [3].

Still significant popularity of HiPPO, as noted by Welle, J. is associated with a low level of data culture, significant interorganizational and intercountry asymmetries of its development. According to Welle, J. developing a data culture is a phased process:

1) data Denial (the organization starts with an active distrust of data and does not use it);

2) data Indifference (the organization has no interest in whether data is collected or used);

3) data Aware (the organization is collecting data and may use it for monitoring, but the organization does not base decisions on it);

4) data Informed (managers use data selectively to aid decision making);

5) data Driven (data plays a central role in as many decisions as possible across the organization) [25]. At the same time, it notes that as the culture of data develops, they actively begin to perform an administrative function [4].

DDDM includes seven main stages of decision making:

1. Definition of the problem, the purpose of management activities.

2. Formulation of the hypothesis or the initial decision matrix [12], the study of the ontology of the problem.

3. Determination of the list of necessary information, data.

4. Construction of the data transfer process.

5. Collection of information, formation of a database, information support for managerial decisions. The effectiveness of managerial decisions is closely related to the quality of the research information base. The quality of the existing research information base depends not only on its quantitative parameters, but also on its relevance and pertinence.

6. Analysis of information support. The quality of the analysis of information support is determined by the relevance of the methods used, the relevance of the results obtained to the purpose of the study. The end result of this step is the construction of the Decision Matrix, which may differ from the initial decision matrix, and the Risk Matrix. However, as Yoe, C. notes, Risk=Consequence×Probability. «... Risk analysis is a process for decision making under uncertainty that consists of three tasks: risk management, risk assessment, and risk communication... risk analysis adds the most value to decision making. This value depends on how much uncertainty the organization faces and the consequences of making a wrong decision» [14].

7. Making managerial decisions based on the assessment and analysis of available alternatives, criteria and other framework conditions for decision-making (Multicriteria Decision-Making (MCDM)) and Effects matrix [4, 7, 12].

The effectiveness of managerial decisions based on information and analytical support, in addition, depends on the data-driven decision making capability (DDDMC) [8] institutions or the subject making the decision. As noted by the team of authors [8], DDDMS institutions or a decision-maker depends on their 5 capabilities:

1) data governance capability;

2) data analytic capability;

3) insight exploitation capability;

4) performance management capability;

5) integration capability [8]. These capabilities are closely related to the stages of DDDM and determine their effectiveness.

DDDMC institutions or a decision-maker can form the basis for the explanation of «The Decision-Making Paradox» [12].

Thus, in order to make an effective managerial decision based on data, the subject, the organization that makes the decision, must have the necessary knowledge, data and information.

Taking into account all of the above, as well as the turbulence of the external environment, bias in judgments, difficulties in intuitive understanding of significant amounts of quantitative and qualitative information, difficulties in making consistent decisions in conditions of uncertainty, entropy [11], the need for transparency and validity of managerial decisions, today there is an urgent need for information and analytical support of managerial decisions.

Information and analytical support of managerial decisions – information about the object of management, obtained from various sources, using various economic and statistical, economic and mathematical methods and models, performs four main functions (descriptive, diagnostic, predictive and administrative [2]) is the basis for making managerial decisions.

In accordance with the functions of information and analytical support, the following types are distinguished:

«Descriptive Analytics: The preliminary stage of data processing in which one extracts historical insights from data and prepares it for more advanced forms of analysis.

Diagnostic Analytics: The branch of data analytics that focuses on determining the causes of phenomena.

Predictive Analytics: The branch of data analytics that focuses on extracting patterns from historical data with the aim of predicting future events.

Prescriptive Analytics: The branch of data analytics that focuses on using data to determine the most appropriate course of action when there's a decision to make» [4].

Today, 90 % of organizations use Descriptive Analytics for DMP [20].

Methods for the formation of information and analytical support were elaborated long time ago, in 1930 [19], depend on its type, the type of managerial decision and other factors.

Most often, when forming information and analytical support, the following methods are used: Factor analysis, Main component analysis (PCA), Correspondence analysis, Canonical analysis, Cluster analysis, Corellium analysis, regression analysis, spectral analysis, Artificial neural networks, network analysis, pattern recognition other.

Thus, the information and analytical support of managerial decisions depends on the subject-object structure of management activities, the subject of managerial decisions, time and other resources, the methodology for collecting and processing information necessary for decision-making.

Public administration as a type of management activity is no exception, and, as a result, requires information and analytical support for managerial decisions.

5.2 INFORMATION AND ANALYTICAL SUPPORT OF MANAGERIAL DECISIONS ON INNOVATIVE DEVELOPMENT AND DEVELOPMENT OF THE INNOVATIVE INFRASTRUCTURE OF UKRAINE

One of the most pressing problems that Ukraine faces today require informed managerial decisions, is the country's innovative development, because it is the country's innovative development and innovativeness that are today the determining factors of socio-economic development, economic growth, components of global competitiveness and ensuring economic security of any country in the world. In 2012–2020 Ukraine has significantly improved its position in the global innovation index, moving from 63rd place in 2012 to 45th place in 2020. As the analysis of the dynamics of the components of the global innovation index shows, the improvement took place both in terms of the available resources and conditions for the implementation of innovative activities (entry sub-index) and the results achieved by this activity (output sub-index). At the same time, the main catalysts for the positive trends in Ukraine's position in the rating were: the institutional environment, the results of creative activity, and market experience was the destructor (**Table 5.1**).

Despite the presence of significant positive trends, Ukraine today is not included in the group of countries leading innovative development, requires further development of its innovative potential, a clear understanding of the country's position in the world, its strategic goal, tools to achieve goals.

The analysis of the dynamics of the global indices of innovativeness of countries, the share of countries in the gross value added created in knowledge-intensive and high-tech industries as the most authoritative and representative indicators of innovative shifts in the development of countries of the world allows to state that modern countries of the world are very differentiated in terms of the level of innovative development.

Based on the clustering method (*K*-means clustering algorithm), three clusters of countries were identified (**Table 5.2**), which differ significantly among themselves in terms of indicators such as the level of innovativeness of the country (according to the World Intellectual Property Organization, as well as the country's share in the gross value added created in knowledge-intensive (knowledge-intensive) and high-tech industries in 2016 and 2018 (2016 and 2018 was selected as the most relevant time interval for which there are relevant statistical observations).

Table 5.1 Global Innovation Index of Ukraine

Indicator	Years										Absolute deviation	
	2012		2014		2016		2018		2020			
	score	place	score	place	score	place	score	place	score	place	score	place
General index	36.1	63	36.3	63	35.7	56	38.5	43	36.3	45	0.22	18
Subindex input1	38	78	38.2	88	38.9	76	40.5	75	40.1	71	2.14	7
Institutional environment	40	117	52.9	103	48.7	101	49.1	107	55.6	93	15.6	24
Human capital and research	42.2	48	36.6	45	40.8	40	37.9	43	40.5	39	–1.7	9
Infrastructure	27.1	98	27.1	107	32.3	99	38.1	89	33.1	94	6	4
Market dawn	38.7	68	45.1	90	42.1	75	42.7	89	42.1	99	3.4	–31
Business dawn	42.3	51	29.1	87	30.6	73	34.5	46	29.5	54	–12.8	–3
Subindex input2	34.2	47	34.4	46	32.5	40	36.6	35	32.5	37	–1.71	10
Scientific and technological results	39.2	30	38.2	32	34.1	33	36.7	27	35.1	25	–4.1	5
Results of creative activity	29.2	83	30.6	77	31	58	36.5	45	29.9	44	0.7	39
Efficiency of innovation	0.9	14	0.9	14	0.8	12	0.9	5	n/a	n/a	–	–

Source: compiled and calculated by the author based on the source data [26, 27]
Note: "+" sign indicates improvement of positions; sign "–" – deterioration

Table 5.2 Cluster analysis results

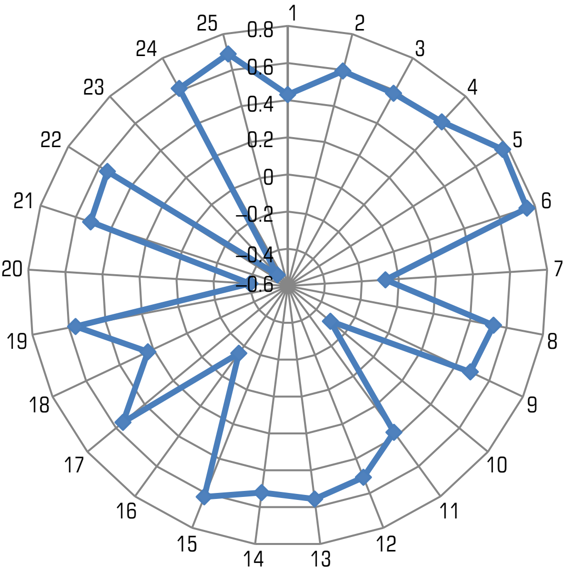
Cluster	Cluster parameters	Country	Note
2016 (73 countries)			
1st Leading countries of innovative development (24)	Average indicator of innovativeness – 55.8 (max – 66.28, min – 49.19) The average share of value added, created in knowledge-intensive and high-tech industries – 3.5 % (max – 31.6%, min – 0.21 %)	Switzerland, Sweden, United Kingdom, United States of America, Finland, Singapore, Ireland, Denmark, Netherlands, Germany, Korea, Canada, Japan, New Zealand, France, Australia, Austria, Israel, Norway, Belgium, China, Czech Republic, Spain, Italy	
2nd Moderate innovators (28)	Average indicator of innovativeness – 37.6 (max – 47.17, min – 33.61) The average share of value added created in knowledge-intensive and high-tech industries – 0.35 % (max – 3.07%, min – 0.03 %)	Portugal, Hungary, Malaysia, Slovakia, Bulgaria, Poland, Greece, United Arab Emirates, Turkey, Russia, Chile, Costa Rica, Romania, Saudi Arabia, Qatar, Thailand, South Africa, **Ukraine**, Bahrain, Vietnam Mexico, Uruguay, Colombia , Georgia, India, Kuwait, Panama, Brazil	
3rd Modest innovators (21)	Average indicator of innovativeness – 27.6 (max – 33.49, min – 22.32) The average share of value added created in science-intensive and high-tech industries – 0.14 % (max – 2.2%, min – 0.01 %)	Peru, Morocco, Oman, Philippines, Tunisia, Iran, Kenya, Argentina, Indonesia, Sri Lanka, Ecuador, Honduras, Ghana, Senegal, Egypt, Bolivia, Nigeria, Bangladesh, Cameroon, Pakistan, Venezuela	
2018 (72 countries)			
1st Leading countries of innovative development (23)	Average indicator of innovativeness – 56.2 (max – 68.4, min – 48.68) The average share of value added, created in knowledge-intensive and high-tech industries – 3.62 % (max – 26.2 %, min – 0.09 %)	Switzerland, Sweden, United Kingdom, United States of America, Finland, Singapore, Ireland, Denmark, Netherlands, Germany, Korea, Canada, Japan, New Zealand, France, Australia, Austria, Israel, Norway, Belgium, China, Czech Republic, Spain	Italy (1→2)
2nd Moderate innovators (24)	Average indicator of innovativeness – 38.95 (max – 46.32, min – 34.27) The average share of value added created in knowledge-intensive and high-tech industries – 0.48 % (max – 2.56 %, min – 0.05 %)	Portugal, Hungary, Malaysia, Slovakia, Bulgaria, Poland, Greece, United Arab Emirates, Turkey, Russia, Chile, Costa Rica, Romania, Saudi Arabia, Qatar, Thailand, South Africa, **Ukraine**, Vietnam, Mexico, Uruguay, India, Kuwait, Italy	Georgia (n/a), Italy (1→2), Brazil (2→3), Colombia (2→3), Panama (2→3), Bahrain (2→3)
3rd Modest innovators (25)	Average indicator of innovativeness – 29 (max – 33.44, min – 23.06) The average share of value added created in science-intensive and high-tech industries – 0.17 % (max – 0.86%, min – 0 %)	Peru, Morocco, Philippines, Tunisia, Iran, Kenya, Argentina, Indonesia, Sri Lanka, Ecuador, Honduras, Senegal, Egypt, Bolivia, Bangladesh, Cameroon, Pakistan, Brazil, Colombia, Panama, Bahrain, Jamaica, Peru, Jordan Zimbabwe	Oman (n/a), Ghana (n/a), Nigeria (n/a), Venezuela (n/a), Brazil (2→3), Colombia (2→3), Panama (2→3), Bahrain (2→3)

Source: compiled and calculated by the authors based on [26–28]

The results of cluster analysis give grounds to assert that in 2016–2018:

1. Countries leading innovative development (Cluster 1) remain almost unchanged. In 2016–2018, this group of countries included such countries as Switzerland, Sweden, Great Britain, the United States of America, Finland, Singapore, Ireland, Denmark, the Netherlands, Germany, Korea, Canada.

2. On the basis of the correlation analysis, the closeness of the relationship between the above factors and the level of innovativeness of the «leading countries of innovative development» was established (**Fig. 5.2**).



1 – Innovative companies
2 – Accelerators
3 – Startups
4 – Park structures
5 – HEI
6 – Science parks
7 – Technological parks
8 – Business angels
9 – Venture funds
10 – The economic growth,%
11 – Productivity (GDP per hour worked), USD
12 – Government spending on R&D, billion USD
13 – Number of engineering firms
14 – Number of consulting firms
15 – GDP per capita, USD per capita
16 – Industrial value added (% of GDP)
17 – Added value created in knowledge-intensive and high-tech industries, billion USD
18 – Export of medium- and high-tech products, billion USD
19 – Import of medium- and high-tech products, billion USD
20 – Foreign trade balance in medium and high-tech goods, billion USD
21 – Exports of high-tech products, billion USD
22 – Import of high-tech products, billion USD
23 – Foreign trade balance in high-tech goods, billion USD
24 – Competitiveness Index (World Economic Forum)
25 – Human development index

Fig. 5.2 Factors affecting the innovative development of countries in Cluster 1
Source: compiled by the author based on [26]

It was found that the list of factors that are characterized by:

– inversely related to the level of innovation of the country, include: the number of technology parks; added value created in industry; the economic growth; the balance of foreign trade in medium- and high-tech goods; balance of foreign trade in high-tech goods, billion dollars;

– direct dependence on the level of innovation of the country, include: the number of innovative companies, accelerators, startups, park structures (science parks), HEI, business angels, venture funds, engineering and consulting firms, labor productivity, GDP per capita, value added, created in science-intensive and high-tech industries, export/import of medium and high-tech products, export/import of high-tech products, the level of human development and competitiveness of the country.

At the same time, it was found that the relationship can be characterized as:

– weak (according to the Chaddock scale, the value of the correlation coefficient varies within 0.1–0.3) between the level of innovation and such indicators of innovative leader countries as: the number of technology parks, value added created in industry; export of medium and high-tech products;

– moderate (in accordance with the Chaddock scale, the value of the correlation coefficient varies between 0.3–0.5) between the level of innovation and such indicators of innovative leaders as: the number of innovative companies, venture capital funds, economic growth, productivity (GDP per hour working hours), the balance of foreign trade in medium- and high-tech goods, billions of dollars;

– a noticeable connection (according to the Chaddock scale, the value of the correlation coefficient varies within 0.5–0.7) between the level of innovation and such indicators of innovative leading countries as: the number of accelerators, start-ups, park structures, business angels, engineering and consulting firms , government spending on R&D, GDP per capita, value added created in science-intensive and high-tech industries, imports of medium and high-tech products, exports and imports of high-tech products, foreign trade balance in high-tech goods, the level of competitiveness and human development;

– a significant relationship (according to the Chaddock scale, the value of the correlation coefficient varies within 0.7–0.9) between the level of innovation and such indicators of innovative leader countries as: the number of HEIs, science parks.

Based on the method of the main components, it was found that the main factors that determined the high level of innovativeness of the countries-innovative leaders are two orthogonal factors: innovation policy and its results; the achieved level of socio-economic development (**Table 5.3**).

The factor «Innovation policy and its results» includes the following components: innovation infrastructure and its architecture, the volume of government spending on R&D; the volume of imports of medium and high-tech goods, exports and imports of high-tech goods; the amount of added value created in knowledge-intensive and high-tech industries.

The factor «Achieved level of socio-economic development» includes: the size of GDP per capita, the level of competitiveness of countries and the level of human development.

These two orthogonal factors together account for more than 86 % of the total variation in the feature sets, vary in their influence on the level of innovativeness of countries. The factor «Innovation policy and its results» is more influential. Thus, the variance of the factor «Innovation policy and its results» is 6.59, the factor «The achieved level of socio-economic development» – 2.89, the contribution of the first factor to the total variance is 60 %, the second – 26 % (**Table 5.4**).

Table 5.3 Results of the implementation of factor analysis

Results of applying factor analysis (principal component analysis) Variable	**Factor Loadings (Varimax raw) Extraction: Principal components (Marked loadings are >0.700000)**	
	Factor (1)	**Factor (2)**
Providing component	0.893781	0.329961
Provided component	0.850802	0.350842
Dual-use component	0.723705	–0.404705
Government spending on R&D	0.932129	–0.323633
Socio-economic development level	–0.055482	0.841673
Added value created in knowledge-intensive and high-tech industries	0.987200	–0.094614
Import of medium and high-tech goods	0.942007	–0.270160
Export of high-tech goods	0.674127	–0.613621
Import of high-tech goods	0.806931	–0.515512
Level of competitiveness	0.205941	0.830507
Human development level	–0.307267	0.916569
Expl.Var	6.022753	3.462962
Prp.Totl	0.547523	0.314815

Source: compiled by the author based on [26]

Table 5.4 Results of applying the method of principal components

Value	**Eigenvalues Extraction: Principal components**			
	Eigenvalue	**Total (variance) (%)**	**Cumulative (Eigenvalue)**	**Cumulative (%)**
1	6.592982	59.93620	6.592982	59.93620
2	2.892733	26.29758	9.485715	86.23377

Source: compiled by the author based on [26]

The results obtained indicate that the country's innovative development is largely not a deterministic, but a controlled process, the main objects of which are the architecture of the innovation infrastructure, the volume of government spending on R&D.

The importance of innovations, ensuring the innovative and technological development of Ukraine is enshrined in a number of strategic regulatory documents: the Strategy for the Development of the Sphere of Innovation for the Period until 2030 [29], the National Economic Strategy for the Period until 2030 [30], the National Security Strategy of Ukraine [31], Human Development Strategy [32], State Strategy for Regional Development for 2021–2027 [33] and others.

Among these strategic regulatory documents, the most systemic, cross-sectoral nature and a decisive importance for ensuring the innovative development of Ukraine is the Strategy for the Development of the Sphere of Innovation for the Period up to 2030 [34], adopted on July 10, 2019. This strategic document aims to ensure «development national innovation ecosystem to ensure the rapid and high-quality transformation of creative ideas into innovative products and services, increasing the level of innovativeness of the national economy…» [34].

One of the main places in this document belongs to the innovation infrastructure as an important condition for ensuring economic growth and development of Ukraine, increasing the level of its innovativeness (the concept of «innovation infrastructure» is found in the Strategy for the Development of the Sphere of Innovation for the Period up to 2030 24 times).

Despite the emphasized importance of the development of innovation infrastructure in the Strategy for the Development of the Sphere of Innovation for the Period up to 2030, the innovation infrastructure today is not a separate object of public administration.

It should be noted that in 2008–2013 there was such an experience in Ukraine – there were special targeted programs for the development of innovative infrastructure: the State Target Economic Program «Creation of Innovative Infrastructure in Ukraine for 2008–2012» and the State Target Economic Program «Creation of Innovative Infrastructure in Ukraine» for 2009–2013 [26].

Failure to understand the importance of considering the innovation infrastructure as a separate object of management leads to a number of negative trends and processes, and, as a result, negatively affects the innovative development of the country and the development of its economy [35–37]. So, in 2008–2018 in Ukraine, there is a decrease in the share of enterprises that produced and sold products new to the market (32.4 % in 2008 and 28.4 % in 2018), a decrease in absolute values and the share of volumes of sold innovative products in the total volume of sold industrial products 5.9 % in 2008 and 0.8 % in 2018) [26, 38].

Under such conditions, managerial decisions on the development of innovative infrastructure require new approaches to their adoption and implementation, and, consequently, to review information and analytical support.

Analysis of factual information presented in sources [26, 38, 39] suggests that in 2008–2018 the innovative infrastructure of Ukraine is characterized by:

1. Deployment. During the analyzed period, the total number of structural elements of the innovation infrastructure increased by 2,551 units: out of 11,574 elements in 2008 up to 14,125 elements (**Table 5.5**).

Table 5.5 Architecture of the innovation infrastructure of Ukraine in 2008–2018

Structural elements of innovation infrastructure	Years										Absolute deviation, 2008–2018	
	2008–2010		2010–2012		2012–2014		2014–2016		2016–2018			
	units	%	units	%	units	%	units	%	units	%	units	%
General index	7,057	61	6,930	63.4	4,084	51	5,195	54.8	8,173	57.9	1,116	–3.1
Subindex input1	4,555	39.4	3,405	31.1	3,278	40.9	3,278	34.6	2,937	20.8	–1,618	–18.6
Institutional environment	4,477	38.7	3,964	36.2	3,876	48.4	4,226	44.5	5,876	41.6	1,399	2.9
Human capital and research	882	7.6	809	7.4	776	9.7	657	6.9	652	4.6	–230	–3
Infrastructure	69	0.6	73	0.7	67	0.8	55	0.6	61	0.4	–8	–0.2
Market dawn	3,526	30.5	3,082	28.2	3,033	37.9	3,514	37	5,163	36.6	1,637	6.1
Business dawn	40	0,3	44	0.4	48	0.6	66	0.7	76	0.5	36	0.2
Subindex input2	92	92	94.7	94.8	85.1	85.1	86.2	86.2	88.6	88.6	–3.4	–3.4

Source: compiled by the authors based on data from [*26*, *38*, *39*]

2. A significant level of imbalance and asymmetry. The innovation infrastructure of Ukraine during the analyzed period is not homogeneous, which is objectively evidenced by the dynamics of the coefficient of variation.

The provided component prevails in the country's innovation infrastructure (on average, 57.62 % of the total number of structural elements of the innovation infrastructure), the smallest is the share of dual-purpose (binary) structures (on average, 0.5 % of the total number of structural elements of the innovation infrastructure).

It should be noted that the leading innovative development countries should have a similar architecture of innovation infrastructure – in the architecture, most of the total number of structural elements of the innovation infrastructure falls on the provided component, the least – on dual-purpose structures. However, the share of dual-use structures and provided structures is much higher.

Thus, the share of structural elements of the provided component accounts for 84.1 % of the total number of structural elements of the innovation infrastructure, which provides 11.9 %, dual-use structures – 4 % [26].

3. The predominance of volumes, an increase in the number of structural elements of the providing component of the innovation infrastructure. During the analyzed period, the number of structural elements of the provided component of the innovation infrastructure increased by 1,116 units, the number of structural elements of the providing component of the innovation infrastructure – by 1,399 units, the number of structural elements of the dual-use component – by 36 units.

It should be noted that the increase in the number of structural elements of the provided component of the innovation infrastructure during the analyzed period occurred due to the increase in the number of enterprises with non-technological innovations. The number of enterprises with technological innovations, also referred to the component «provided structures», is actively decreasing (by 1,618 units), which is a very negative process, because it is this category of enterprises that has the most technologically innovative potential.

The most numerous group of enterprises engaged in innovative activities are small enterprises, as well as enterprises with marketing and organizational innovations [26]. The increase in the number of structural elements of the providing component of the innovation infrastructure is associated with an increase in the group of structural elements of the specified component, with the exception of the HEI and business incubators. The number of HEIs and business incubators during the analyzed period decreased by 230 and 8 units, respectively. Development of innovation infrastructure in 2008–2018 was characterized by significant regional and sectoral asymmetry.

In 2008–2018 the highest level of innovation activity of enterprises was recorded in such regions as the Dnipropetrovsk region (on average 15.5 % of the total number of surveyed enterprises in the corresponding region), Zaporizhzhia region (14.32 % of the total number of surveyed enterprises in the corresponding region), Ivano-Frankivsk region (14.28 % of the total number of surveyed enterprises in the corresponding region), Kyiv region (15.6 % of the total number of surveyed enterprises in the corresponding region), Kirovohrad region (14.32 % of the total number of surveyed enterprises in the corresponding region), Lviv region (14,92 % of the total number of surveyed enterprises in the corresponding region), Rivne region (14.04 % of the total number of surveyed enterprises in the corresponding region), Kharkiv region (18.1 % of the total number of surveyed enterprises in the corresponding region), Kyiv city (21.04 % of the total number of surveyed enterprises about the region).

The lowest level of innovation activity of enterprises was recorded in such regions as Cherkasy region (9.84 % of the total number of surveyed enterprises in the corresponding region), Chernivtsi region (9.74 % of the total number of surveyed enterprises in the corresponding region) (**Table 5.6**). The largest number of innovatively active enterprises during the analyzed period was recorded in Dnipropetrovsk, Kyiv, Lviv, Odesa, Kharkiv regions, Kyiv city, the smallest – Kherson, Chernivtsi regions.

During the analyzed period, the number of innovatively active enterprises in Ukraine as a whole increased, which was associated with the corresponding trends in the Dnipropetrovsk, Zhytomyr, Zaporizhzhia, Ivano-Frankivsk, Kyiv, Kirovohrad, Lviv, Poltava, Ternopil, Kharkiv, Kherson, Khmelnytskyi, Chernihiv regions.

The largest volumes of sold innovative products were recorded in Donetsk, Dnipropetrovsk, Zaporizhzia and Kharkiv regions [26].

The leading regions in terms of the share of the volume of sold innovative products in the total volume of products sold by industrial enterprises of the region are Donetsk, Zakarpattia, Zaporizhzhia, Ivano-Frankivsk, Kirovohrad, Sumy, Ternopil, Kharkiv, Cherkasy regions [26].

Table 5.6 Innovative activity of enterprises by region,% of the total number of surveyed enterprises in the corresponding region

Region	2008–2010		2010–2012		2012–2014		2014–2016		2016–2018		Average value		Absolute deviation	
	%	unis	%	unis	%	unis	%	unis	%	unis	%	unis	%	unis
Total	21	7,640	20.4	6,930	14.6	4,084	18.4	5,095	28.1	8,173	20.5	6,384	7.1	533
Autonomous Republic of Crimea	2.5	188	2.2	151	n/a	n/a	n/a	n/a	n/a	n/a	2.35	68	–	–188
Vinnytsia	3.1	240	3	208	17.3	146	15.2	123	24.2	203	12.56	184	21.1	–37
Volyn	2.2	170	1.9	135	13.3	74	14.4	75	26	143	11.56	119	23.8	–27
Dnipropetrovsk	8.3	631	7.9	545	13.3	343	19	476	29	776	15.5	554	20.7	145
Donetsk	7.9	603	8.1	564	12.9	45	11	86	17.9	145	11.56	289	10	–458
Zhytomyr	1.8	139	2	139	13.9	99	17.7	137	23.7	187	11.82	140	21.9	48
Zakarpattia	2.1	164	1.4	100	11.9	66	13.8	78	26.9	149	11.22	111	24.8	–15
Zaporizhzia	1.7	133	4.9	338	18.8	244	17.5	206	28.7	352	14.32	255	27	219
Ivano-Frankivsk	0.9	69	2.6	178	21.1	134	19.7	121	27.1	177	14.28	136	26.2	108
Kyiv	4.8	364	6.6	455	18.1	268	17.7	260	30.8	520	15.6	373	26	156
Kirovohrad	1.2	94	1.4	95	16.9	84	19.3	92	32.8	164	14.32	106	31.6	70
Lugansk	3.9	297	2.9	201	15	6	12.6	34	21.8	61	11.24	120	17.9	–236
Lviv	5	381	6.2	432	15.9	304	18.4	336	29.1	544	14.92	399	24.1	163
Mykolaiv	2.1	162	2.6	181	16.3	109	15.4	96	20.9	133	11.46	136	18.8	–29
Odesa	5.9	448	3.8	261	12.6	215	16.3	267	22.7	357	12.26	310	16.8	–91
Poltava	2.3	175	1.7	117	6.6	60	18.4	157	23.6	217	10.52	145	21.3	42
Rivne	2.2	166	2.5	171	23.9	149	23.8	137	17.8	105	14.04	146	15.6	–61
Sumy	1.9	144	1.5	107	11.5	65	17.2	93	25.4	142	11.5	110	23.5	–2
Ternopil	1.6	123	1.4	95	15.2	78	19.9	97	31.6	156	13.94	110	30	33
Kharkiv	7.5	571	8.6	596	20.9	457	23.4	479	30.1	670	18.1	555	22.6	99
Kherson	1.2	88	1.4	94	14.7	73	16.1	78	26.1	127	11.9	92	24.9	39
Khmelnytskyi	1.9	142	2.4	166	10.9	80	12.8	86	23.6	166	10.32	128	21.7	24
Cherkasy	2.1	158	2	142	11.6	85	11.8	81	21.7	155	9.84	124	19.6	–3
Chernivtsi	1.2	94	1.3	93	16.4	66	9.7	36	20.1	76	9.74	73	18.9	–18
Chernihiv	1.4	105	1.8	127	17.7	101	16.5	89	24.4	140	12.36	112	23	35
Kyiv City	21.9	1,672	16.8	1,166	11.4	733	21.4	1,375	33.7	2,308	21.04	1,451	11.8	636
Sevastopol City	1.6	121	1.1	73	n/a	–	n/a	n/a	n/a	n/a	1.35	n/a	–	n/a
KVIIR	113.7	113.7	93.7	93.7	25.1	98.1	21.5	133.6	17.2	138.8	20.2	113.6	113.7	113.7

Source: compiled by the authors based on data from [*26*, *38*, *39*]

As of 01.01.2019, the leading regions (**Table 5.7**) by: the number of business centers were Dnipropetrovsk, Donetsk, Kharkiv regions, Kyiv; the number of business incubators was Dnipropetrovsk, Zaporizhzhia, Sumy regions; the number of technoparks/industrial parks was Donetsk, Kyiv, Poltava, Kharkiv regions, Kyiv; the number of innovative funds and companies were Donetsk, Poltava, Cherkasy regions, Kyiv; the number of information and consulting institutions were Vinnytsia, Donetsk, Poltava, Kharkiv, Kherson regions, Kyiv; the number of leasing centers was Donetsk and Dnipropetrovsk regions; the number of higher educational institutions were Dnipropetrovsk, Zaporizhzhia, Lviv, Odesa, Kharkiv regions, Kyiv [38].

Table 5.7 Regional features of the development of individual elements of the innovation infrastructure (as of 01.01.2019)

Regions	**Business centers**	**Business incubators**	**Technoparks / industrial parks**	**Leasing centers**	**Entrepreneur-ship support funds**	**Investment funds and companies**	**Innovation funds and companies**	**Information consulting institutions**	**Total public associations of entrepreneurs**	**Coordination councils**
Vinnytsia	5	–	4	3	9	48	33	457	80	34
Volyn	2	2	–	–	5	–	–	1	28	15
Dnipropetrovsk	54	7	1	19	1	1	–	10	58	39
Donetsk	20	3	9	30	1	237	121	599	65	19
Zhytomyr	2	1	2	4	2	7	8	257	112	29
Zakarpattia	2	2	–	3	3	27	22	117	–	–
Zaporizhzhia	2	6	–	2	1	20	2	15	75	27
Ivano-Frankivsk	18	3	2	4	7	–	–	78	64	20
Kyiv	9	5	26	12	8	10	4	88	78	38
Kirovohrad	5	–	1	–	3	–	12	47	52	26
Luhansk	9	–	–	–	–	–	–	13	38	4
Lviv	17	1	3	9	8	2	–	22	60	32
Mykolaiv	14	2	–	1	8	14	62	65	–	
Odesa	31	–	–	–	4	–	–	–	38	1
Poltava	11	4	6	5	13	62	35	615	2,708	32
Rivne	1	1	1	–	–	24	2	10	42	21
Sumy	4	5	–	3	7	5	2	21	76	26
Ternopil	7	3	–	–	1	10	–	18	30	17
Kharkiv	26	1	18	9	8	142	2	328	48	15
Kherson	1	3	1	–	7	19	9	1	112	23
Khmelnytskyi	3	1	2	4	1	–	1	151	62	27
Cherkasy	5	3	–	3	2	1	38	5	56	26
Chernivtsi	7	1	1	1	10	2	2	26	57	13
Chernihiv	2	–	–	–	2	–	–	4	47	24
Kyiv City	157	13	33	429	57	1,466	476	658	310	11

Source: [*26*, *39*]

In 2008–2018, most of the innovatively active enterprises were concentrated in the processing industry (23.9 % of the total number of surveyed enterprises of the corresponding type of activity), information and telecommunications (22.9 % of the total number of surveyed enterprises of the corresponding type of activity), financial and insurance activities (26.6 % of the total number of surveyed enterprises of the corresponding type of activity) (**Table 5.8**).

Table 5.8 Innovative activity of enterprises by type of activity, in % of the total number of surveyed enterprises of the corresponding type of activ

Indicators	2008–2010	2012–2014	2014–2016	2016–2018	Absolute deviation	Average value
Total	21	14.6	18.4	28.1	7.1	20.5
Mining and quarrying	12.8	11.9	14.2	21.9	9.1	15.2
Processing industry	21.5	20.3	21.9	31.8	10.3	23.9
Supply of electricity, gas and air conditioning	n/a	18.6	15.4	20	–	18.0
Water supply, sewerage, waste management	n/a	10.2	9.8	15.8	–	11.9
Wholesale trade, except trade in motor vehicles and motorcycles	15.9	11.2	17.3	30.1	14.2	18.6
Transport, warehousing, postal and courier activities	12.9	7.3	9.7	15.5	2.6	11.4
Information and telecommunications	21.7	16.3	22.1	31.5	9.8	22.9
Financial and insurance activities	19.7	n/a	21.7	38.3	18.6	26.6
Architectural activities, technical testing and research, research and development, advertising and market research	n/a	12.8	20.1	27.1	–	20.0
Coefficient of industry variation of the structural elements of the provided component of the innovation infrastructure	25.4	32.7	29.3	26.4	–	28.45

Source: compiled and calculated by the author based on these sources [*26*, *38*]

5.3 STRATEGY FOR THE DEVELOPMENT OF INNOVATIVE INFRASTRUCTURE IN UKRAINE

The presence of significant asymmetries and imbalances in the development of the innovation infrastructure of Ukraine, the low efficiency of its development, the presence of threatening trends determine the need to develop a strategy for the development of the innovation infrastructure (**Fig. 5.3**).

Taking into account all of the above, incl. features of the development of the innovative infrastructure of the leading countries of innovative development, the strategy for the development of the innovative infrastructure of Ukraine to provide for the cumulative nature of the transformations, which means it is an iterative model of actions and a set of mechanisms for implementing strategic priorities that ensure the achievement of long-term goals for the development of the innovative infrastructure of the national economy, their congruence with opportunities and limitations the functioning of the innovation infrastructure on the principles of synergy and self-organization, multilevel; cyclicality; the priority of ensuring national security; taking into account the influence of globalization, vectors (external, internal) and dimensions (temporal, material, spatial, structural) of the innovation infrastructure.

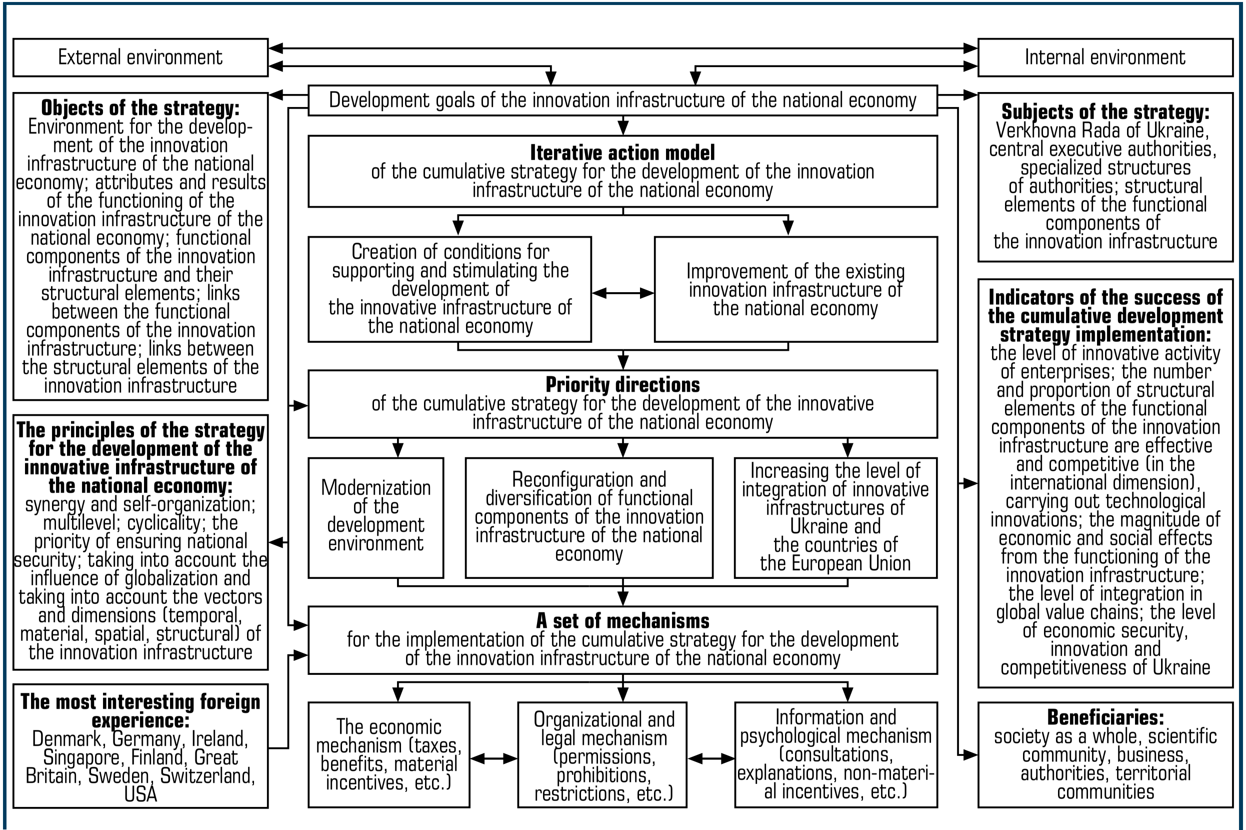


Fig. 5.3 Cumulative strategy for the development of the innovative infrastructure of the national economy [*26*]

A cumulative strategy for the development of an innovative infrastructure of Ukraine should focus on the following areas: reconfiguration and diversification of functional components of the infrastructure, improving the institutional environment for the development of innovative infrastructure [26], increasing the competitiveness of the structural elements of the innovation infrastructure.

At the same time, the reconfiguration of the functional components of the infrastructure should be carried out taking into account the availability of strategic alternatives presented in **Fig. 5.4**.

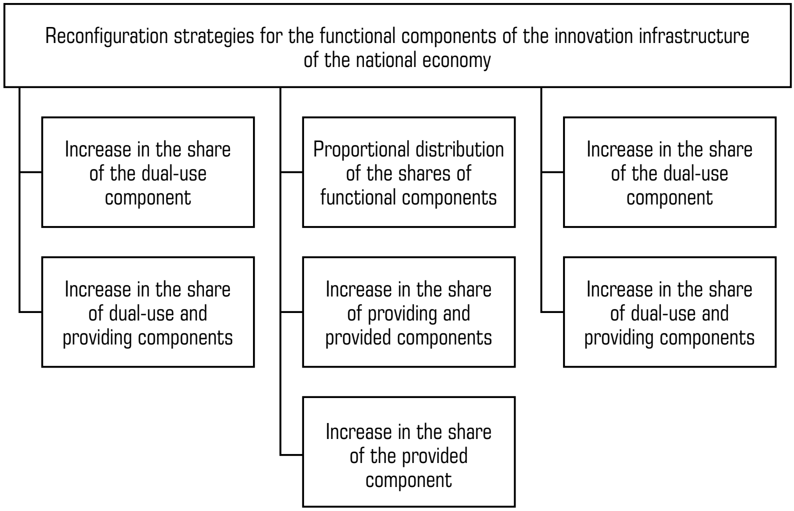


Fig. 5.4 Strategic alternatives for reconfiguring the functional components of the innovation infrastructure of the national economy
Source: compiled by the authors

On the basis of correlation-regression analysis, calculation of partial elasticity coefficients, it was found that the greatest value for increasing the volume of added value in knowledge-intensive and high-tech industries, the export of medium- and high-tech goods, high-tech exports, and, as a consequence, the country's innovativeness has an increase in the number, primarily turn, competitive providing structures (higher education institutions (HEI), business angels, venture capital funds), dual-use structures, as well as enterprises engaged in innovative activities [26] (**Table 5.9**).

Thus, the reconfiguration of the functional components of the infrastructure of Ukraine should be carried out on the basis of increasing the share of the dual-use component and the providing component of the innovation infrastructure.

Table 5.9 Justification of the directions of reconfiguration and diversification of the functional components of the infrastructure

Variables			X						Providing structures						Provided structures		Dual-use structures	
			Provided/ Providing structures	Provided d structures/ Dual-use structures	Dual-use structures/Providing structures supporting structures	Providing structures	Provided structures	Dual-use structures	Accelerators	HEI	Business angels	Venture funds	Engineering firms	Consulting firms	Enterprises engaged in innovative activities	Startups	Science parks	Technological parks
			X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
Y	Value added in knowledge-intensive and high-tech industries, billion USD (Y_1)	*n*	24			24			24						24		24	
		Regression	$Y_1=1072.975-164.0281X_1+ +14.4036X_2+1,095.6028X_3$			$Y_1=-96.0589+ +30.776X_4-3.215X_5+ +25.1896X_6$			$Y_1=-30.4915-2.5892X_7+17.6891X_8+ +300.2626X_9+127.0497X_{10}-239.1207X_{11}- -243.2002X_{12}$						$Y_1=72.331+16.9934X_{13}+ +0.306X_{14}$		$Y_1=-64.6338+ +78.1949X_{15}+11.5146X_{16}$	
		Standardized regression	$ty_1=-0.356x_1+0.32x_2+0.282x_3$			$ty_1=2.08x_4- 1.451x_5+0.379x_6$			$ty_1=-0.0522x_7+0.36x_8+3.402x_9+0.541x_{10}- -1.752x_{11}-1.564x_{12}$						$ty_1=0.839x_{13}+0.128x_{14}$		$ty_1=0.776x_{15}+0.0876x_{16}$	
		R^2	0.07761			0.9032			0.996						0.8945		0.6739	
		Ei, |*Ei*|>1	–1.43	0.58	0.56	1.99	–1.47	0.55	–0.05	0.54	1.49	0.38	–0.72	–0.64	0.79	0.13	0.97	0.11
		F>*Fcr*	0.56<3.1			62.21>3.1			699.36>2.7						88.99>3.49		21.7>3.49	
	Export of medium and high-tech goods, billion USD (Y_2)	*n*	12			12			12						12		12	
		Regression	$Y_2=227.2455-55.5567X_1+ +5.1591X_2+455.5594X_3$			$Y_2=84.8916+4.7974X_4- -0.7565X_5+4.7963X_6$			$Y_2=33.047-3.9453X_7+3.1882X_8+46.1313X_9+ +28.2505X_{10}-36.5865X_{11}-50.611X_{12}$						$Y_2=131.8074+2.4685X_{13}- -0.217X_{14}$		$Y_2=63.9054+3.0235X_{15}+ +4.9408X_{16}$	
		Standardized regression	$ty_2=-1.056x_1+0.915x_2+ +0.923x_3$			$ty_2=3.438x_4-3.717x_5+ +0.696x_6$			$ty_2=-0.846x_7+0.637x_8+5.774x_9+1.272x_{10}- -2.971x_{11}-3.617x_{12}$						$ty_2=1.263x_{13}-0.981x_{14}$		$ty_2=0.301x_{15}+0.371x_{16}$	
		R^2	0.79			0.6847			0.915						0.6154		0.305	
		Ei, |*Ei*|>1	–2.36	0.96	1.14	2.40	–2.69	0.81	–0.60	0.72	2.11	0.77	–1.01	–1.17	0.96	–0.69	0.28	0.37
		F>*Fcr*	10.03>4.07			5.79>4.07			8.97>4.95						7.2>4.26		1.97<4.26	
	High-tech export, billion USD (Y_3)	*n*	12			12			12						12		12	
		Regression	$Y_3=88.9693-41.6957X_1+ +5.1203X_2+442.7499X_3$			$Y_3=38.2255+2.7751X_4- -0.4325X_5+4.2026X_6$			$Y_3=124.7457-3.7634X_7-0.07838X_8+ +50.1658X_9++3.4608X_{10}+12.8027X_{11}- -89.3891X_{12}$						$Y_3=92.3422+1.5422X_{13}- -0.1034X_{14}$		$Y_3=23.7489+2.8197X_{15}+ +5.2696X_{16}$	
		Standardized regression	$ty_3=-0.947x_1+1.085x_2+ +1.073x_3$			$ty_3=2.376x_4-2.526x_5+ +0.728x_6$			$ty_3=-0.964x_7-0.0187x_8+7.502x_9+0.186x_{10}+ +1.242x_{11}-7.633x_{12}$						$ty_3=0.943x_{13}-0.555x_{14}$		$ty_3=0.335x_{15}+0.473x_{16}$	
		R^2	0.7757			0.587			0.9699						0.3764		0.445	
		Ei, |*Ei*|>1	–2.26	1.22	1.42	1.77	–1.96	0.901	–0.73	–0.02	2.93	0.12	0.45	–2.63	0.76	–0.42	0.33	0.5
		F>*Fcr*	9.22>4.07			3.79<4.07			26.84>4.95						2.72<4.26		3.61<4.26	

Note: n – the number of observations; R^2 – coefficient of determination; Ei – coefficient of elasticity; F – F-criterion (empirical value); F_{cr} – F-criterion (critical value)
Source: [26]

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