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Article

Methods and Criteria for Assessing The Level of Innovative Activity of The Pharmaceutical Industry of Surkhandarya Region

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Abstract: This study aims to develop robust methods and criteria for assessing the level of innovative activity within the pharmaceutical industry of the Surkhandarya region. The research employs econometric and economic-statistical models to quantify innovation performance and identify key determinants influencing innovation adoption. Novelty lies in the formulation of a comprehensive assessment framework tailored specifically to the regional pharmaceutical sector, which has been underrepresented in prior studies. The findings reveal current gaps in innovation activity and provide actionable insights for policymakers and industry stakeholders. Scientific proposals and recommendations are presented to enhance the innovative potential of local pharmaceutical enterprises, including strategies for technology adoption, research and development prioritization, and human capital development. The implications of this research are significant for both regional economic growth and the competitiveness of the pharmaceutical industry, providing a foundation for evidence-based policy and management decisions. This study contributes to the literature on regional innovation systems by offering a practical model for evaluating and fostering innovation in the pharmaceutical sector.

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1. Introduction

The pharmaceutical industry has become one of the most knowledge-intensive and skill-intensive sectors of the economy in recent years. The processes of manufacturing, clinical trials and marketing of pharmaceutical products require high scientific potential, modern technologies and qualified personnel [1]. Accordingly, during our study, we assessed the implementation of econometric evaluation processes of innovative activity indicators in the pharmaceutical sector in the regions through complex indices as a scientifically sound approach. The "Pharmaceutical Innovation Activity Index (FIFI)" indicator proposed by us will help determine the level of innovative development of the regional pharmaceutical industry based on a systematic and multi-factor assessment.

2. Materials and Methods

In the economic scientific literature, the issues of identifying the development trends of the main indicators of the pharmaceutical industry and their assessment based on econometric methods have been widely studied by foreign and domestic scientists, and empirical analyses in this area have been scientifically substantiated using economic and statistical methods. As an example, we can cite the scientific works of F.Abdiyeva, O.S.Khomidov, O.A.Abdug'aniyev, N.M.Mahmudov, Yu.B.Bakhriddinova, L.A.Vibornova, O.S.Malochova, Y.A.Roslyakova, N.Varshney, D.Jain, Dr.Pracheta and D.Mitra, which analyze the development trends and main indicators of the pharmaceutical industry [2]. In the above scientific works, scientists analyzed these issues based on economic and statistical methods and sought to scientifically illuminate the specific content and main characteristics of the development indicators of the industry.

For example, one of our country's leading economists, F.Abdiyeva, pays special attention in her works to the activities of the pharmaceutical industry and the importance of creating an investment climate in this sector [3].

In his work, O.S. Khomidov deeply analyzed the scientific and theoretical foundations of research and modeling the sustainable economic development of the pharmaceutical industry in the regions[4].

O.A. Abduganiyev also touched upon the development of the pharmaceutical industry in his research work entitled "Econometric models for increasing the efficiency of production of agricultural products included in the consumer basket [5]."

Research methodology

The main objective of the study is to develop scientific and practical proposals and recommendations for the development of the pharmaceutical industry in the regions. Economic and statistical methods were widely used in the research process.

3. Results and Discussion

At the first stage, the standardized values of the indicators were calculated using the system of indicators proposed by us, and their overall average values were determined. During our research, we formulated the level of the pharmaceutical innovation activity index on the example of Surkhandarya region based on four main components. These are: Scientific and research activity; Technological innovation; Product innovation rate; Human resource capacity [6].

The indicator of scientific and research activity (ITF) is one of the main indicators determining the innovative development of the pharmaceutical industry. This is because any innovative medicinal products or pharmaceutical technologies are created as a result of scientific research. These processes include the stages of identifying new biologically active substances, studying their pharmacological properties, assessing their safety and efficacy, and introducing them into production on an industrial scale [7]. Increasing scientific and research activity creates the basis for technological modernization of the pharmaceutical industry in Surkhandarya region, increasing production efficiency, and ensuring the competitiveness of products. Typically, a high level of this indicator increases the possibility of reducing production costs, increasing the volume of import-substituting products, and creating innovative pharmaceutical products aimed at export. It also has a positive effect on the development of scientific research for the region and the training of highly qualified scientific personnel [8]. From the above, we can conclude that the indicator of scientific and research activity is of great importance in ensuring the sustainable and innovative development of the pharmaceutical industry in Surkhandarya region.

Table 1 below allows us to analyze the situation of Surkhandarya region in comparison with the regions that have achieved the best results in this area, based on the main indicators assessing innovative activity in the pharmaceutical sector - the share of expenditures directed to innovative research (XU), the number of patents (PS), and the number of products in clinical trials (MS).

Table 1. Indicators for assessing research activity and their values

Indicators	**Share of spending on innovative research**	**Number of patents**	**Number of products in clinical trials**
Marking	XU	PS	MS
Classification	Share of funds spent on scientific research within total expenditures (in percent)	Number of patented new drugs or technologies (units)	Number of new drugs in development (units)
Indicator value for the best area	5%	10	8
Indicator values for Surkhandarya region	2,1%	3	4
Normalized values	0,42	0,30	0,50

The indicator of the share of expenditures directed to innovative research, presented in Table 1, represents the share of funds allocated for scientific and research work in the total expenditures of the studied region. As a result of the analysis, it was found that in the best region this indicator was 5 percent, indicating that scientific and innovative activities are a priority in this region. In Surkhandarya region, the share of expenditures directed to innovative research was only 2.1 percent, with a normalized value of 0.42. This situation indicates that investments in scientific research are not sufficiently directed in the region and that additional financial incentives need to be strengthened to increase innovative potential [9]. The indicator of the number of patents represents the innovative effectiveness, that is, the level of legal protection of new medicines or technologies. While in the best region the number of patents was 10, in Surkhandarya region this indicator was only 3. As a result, the normalized value is 0.30, which is the lowest among these indicators. This indicates that scientific developments in the region are not being sufficiently commercialized or that patenting processes are slow [10]. The indicator of the number of products in clinical trials reflects the number of new drugs that are actually being produced in the pharmaceutical sector and are about to enter the market. While in the best region this indicator is 8, in Surkhandarya region it is 4. The normalized value is 0.5, which indicates a better situation compared to other indicators. So, if we conclude from this, the region has the potential to bring new products to the practical stage, but to support this process, it is necessary to closely link it with scientific research and patenting [11], [12].

Based on the results of the above analysis, the average value of scientific research activity for Surkhandarya region was calculated based on the following formula:

$$\mathbf{ITF} = \frac{\mathbf{XU + PS + MS}}{\mathbf{3}}$$

here, **ITF** - coefficient of the level of scientific and research activity of the region;

XU - share of expenditures directed to innovative research;

PS - number of patented new drugs or technologies;

MS - number of products in clinical trials.

Based on the above formula, the coefficient of scientific and research activity in the development of the pharmaceutical industry of Surkhandarya region was determined.

$$\mathbf{IRT} = \frac{\mathbf{0,42 + 0,30 + 0,50}}{\mathbf{3}} = \mathbf{0,406}$$

This result indicates that the level of innovative development in the pharmaceutical sector of Surkhandarya region is medium-low. That is, taking into account that the maximum value of the index can be equal to 1, the current result means that approximately 40.6 percent of the region's innovative potential is being used in practice.

When analyzing the components of the R&D activity indicator, the low formation of the index is negatively affected by the number of patents (PS = 0.30). This indicates that the level of formalization and protection of scientific results in the region is insufficient. The share of expenditures directed to innovative research (XU = 0.42) is also below the optimal level, indicating limited financial resources allocated for scientific research. The number of products in clinical trials (MS = 0.50) is relatively high, confirming the potential for practical development of new drugs in the region [13].

In conclusion, the calculated R&D activity index (ITF = 0.406) justifies the need to implement systematic measures to accelerate innovation processes in the pharmaceutical sector in Surkhandarya region. In particular, the level of R&D activity can be significantly improved by increasing spending on innovative research, stimulating patenting activities, and effectively commercializing the results of clinical trials.

The technological innovation (TY) indicator is an important indicator that reflects the level of technological modernization being carried out in the pharmaceutical industry. Currently, technological innovations in this area in Surkhandarya region are not satisfactory. Although digitalization processes are developing relatively rapidly, deep technological modernization of production has not been implemented to a sufficient extent. Therefore, in order to effectively continue technological innovations, it is necessary to increase the volume of investments, accelerate the processes of technical re-equipment of production, and set adaptation to international standards as a priority [14]. The process of modernization of the pharmaceutical industry in Surkhandarya region has begun and positive developments are observed in some areas, but this process has not yet reached a complete and systematic stage. It is these aspects that determine the relevance of the technological innovation indicator and justify the need for its in-depth analysis during the study.

Table 2 below analyzes the situation of Surkhandarya region in comparison with the regions that have achieved the best results in this area, based on the main indicators assessing the state of technological innovation - the share of production lines that meet international standards (LU), the share of automated processes (AJU), and the share of digitalized technologies (RTU).

Table 2. Indicators required to assess the state of technological innovation

Indicators	**Share of GMP certified lines**	**Share of automated processes**	**Share of digitized technologies**
Marking	LU	AJU	RTU
Classification	Percentage of production processes meeting international quality and safety standards	Share of direct correlation with reducing the level of dependence on the human factor in production and increasing efficiency (in percent)	Level of use of information technologies in production, management and control processes (in percent)
Indicator value for the best area	100%	100%	100%
Indicator values for Surkhandarya region	40%	35%	50%
Normalized values	0,40	0,35	0,50

Table 2 includes three main indicators assessing the level of technological innovation: the share of production processes that comply with international quality and safety standards (GMP certified lines) (LU); the share of automated processes (AJU); the share of digitalized technologies (RTU). These indicators allow us to analyze the current state of pharmaceutical production in Surkhandarya region. The share of GMP certified lines (LU) reflects the compliance of production processes with international quality and safety standards. When the highest value is taken as 100 percent, this indicator in Surkhandarya region was 40 percent. On this basis, it was concluded that the normalized value is equal to 0.40. We can conclude that although the region has modern and international production lines, their share is still insufficient and that a deep modernization of the production infrastructure is necessary. The share of automated processes (AJU) indicator is directly related to reducing dependence on the human factor in production, increasing labor productivity and minimizing technological errors [15]. In Surkhandarya region, this indicator was 35 percent. The normalized value is 0.35, which shows the lowest result in the table. This indicates a low level of technological innovation and the need to increase the level of automation. The next indicator, the share of digitized technologies (RTU), usually reflects the level of use of information technologies in production and control processes. This indicator is 50 percent in Surkhandarya region, and the normalized value is 0.50.

Our analysis shows that technological innovation in Surkhandarya region is not developing evenly. There are positive results in the field of digitalization, but the level of adaptation to GMP standards is low. Accordingly, it is necessary to modernize production. For this, it is necessary to increase investments, and it is important to introduce automation technologies. Expanding GMP certification processes is also of great importance.

During our study, we used the following formula to determine the average cost for technological innovation:

$$\mathbf{TY} = \frac{\mathbf{LU} + \mathbf{AJU} + \mathbf{RTU}}{\mathbf{3}}$$

where, **TY** - coefficient of the level of technological modernization carried out in the pharmaceutical industry of the region;

LU - share of GMP certified lines (share of compliance of production processes with international quality and safety standards);

AJU - share of automated processes;

RTU - share of digitalized technologies.

$$\mathbf{TY} = \frac{\mathbf{0,40 + 0,35 + 0,50}}{\mathbf{3}} = \mathbf{0,416}$$

Based on the above formula, the coefficient of the level of technological modernization in the pharmaceutical industry of Surkhandarya region was determined.

In general, the analysis of the average value of normalized values (TY=0.416) shows that technological innovations in Surkhandarya region are developing unevenly. Despite the relatively positive trend in digitalization, the level of adaptation to GMP standards and automation remains low. To stabilize these indicators, it is necessary to strengthen technological innovations, modernize production, increase investments in the industry, introduce automation technologies, and expand GMP certification processes.

Product innovation rate (MYT) is an indicator of how quickly and regularly the product range is updated in the pharmaceutical industry. This indicator assesses the level of development of new drugs, new dosage forms of existing drugs, improved formulations, bioequivalent analogues, and adaptation to market and medical needs.

Table 3 below examines and analyzes the situation in Surkhandarya region in terms of the main indicators assessing the product innovation rate: the share of new drug names (DNU) and the share of modernized forms (MU).

Table 3. Indicators needed to assess the rate of product innovation

Indicators	**Share of new drug names**	**Share of modernized forms**
Marking	DNU	MU
Classification	It reflects the share of the total type of completely new drugs introduced into	Represents the share of improved forms of existing drugs (new dosage forms, packaging, combination

	production during a certain period.	formulations, or variants with improved pharmacokinetic properties)
Indicator value for the best area	30%	40%
Indicator values for Surkhandarya region	12%	18%
Normalized values	0,40	0,45

The share of new drug names usually indicates the share of new drugs introduced into production by pharmaceutical enterprises in the total number of drugs. If the maximum value is set at 30 percent, then in Surkhandarya region this indicator was 12 percent. As a result, the normalized value is 0.40, which indicates that the pace of new drug development is low compared to existing capabilities. If the maximum value is 40%, then in Surkhandarya region this indicator is 18% and the normalized score is 0.45. This means that the modernization processes in the region are somewhat more active in terms of new drug development.

The integral indicator of MYT was calculated as follows:

$$\mathbf{MYT} = \frac{\mathbf{DNU + MU}}{\mathbf{2}}$$

where, **MYT** - the coefficient of the rate of product renewal in the pharmaceutical industry of the region;

DNU - the total share of completely new drugs introduced into production in a certain period;

MU - the share of modernized forms.

Based on the above formula, the coefficient of the level of technological modernization, which is carried out, is determined by how quickly and regularly the product range is updated in the pharmaceutical industry of Surkhandarya region.

$$\mathbf{MYT} = \frac{\mathbf{0,40 + 0,45}}{\mathbf{2}} = \mathbf{0,425}$$

The calculated value (MYT=0.425) indicates that the rate of renewal of pharmaceutical products in Surkhandarya region is at an average-low level. This means that although there is a process of renewal of the range of pharmaceutical products in the region, it has not reached the level of leading regions. The renewal of pharmaceutical products in Surkhandarya region is carried out mainly through the modernization of existing drugs. The possibility of developing completely new drugs is limited. We believe that in order to increase the rate of renewal of pharmaceutical products in Surkhandarya region, it is necessary to strengthen research and development, activate clinical trials and patenting processes, and develop mechanisms for faster introduction of innovative products to the market.

The indicator of personnel competence (KS) is one of the most important factors of innovative development in the pharmaceutical industry, reflecting the share of specialists with scientific knowledge and the level of continuous improvement of professional qualifications of employees. By increasing this indicator, the regions will have an opportunity to develop new medicines, introduce modern technologies and establish production in accordance with quality standards. Table 4 analyzes the situation in Surkhandarya region in terms of the main indicators assessing the rate of product innovation: the share of specialists with scientific degrees (IDMU) and the share of employees with advanced training (MOXU).

Table 4. Indicators required for assessing human resource capacity in the pharmaceutical industry

Indicators	Ilmiy darajaga ega mutaxassislar ulushi	Malaka oshirgan xodimlar ulushi
Marking	IDMU	MOXU
Classification	Represents the proportion of employees with an academic degree, such as a Doctor of Science or Doctor of Philosophy (PhD), working in pharmaceutical companies	Reflects the level of retraining, advanced training, or training in modern technologies among employees in recent years
Indicator value for the best area	15%	80%
Indicator values for Surkhandarya region	6%	48%
Normalized values	0,40	0,60

The percentage of specialists with scientific degrees presented in Table 4 represents the share of employees with scientific degrees, such as Doctor of Science (DSc) or Doctor of Philosophy (PhD), working in pharmaceutical enterprises. If the upper value is set at 15 percent, then this indicator was 6 percent in Surkhandarya region. As a result, the normalized score is 0.40, which indicates that the scientific potential in the region is not sufficiently formed. The indicator of the percentage of employees with advanced training reflects the degree to which employees have undergone retraining, advanced training or training in modern technologies in recent years. In Surkhandarya region, this indicator was 48 percent. This is equal to 0.60, compared to the maximum of 80 percent. From this we can conclude that the system of personnel training and advanced training in the region is relatively active.

The integral indicator of personnel potential was calculated based on the following formula.

$$\mathbf{KS} = \frac{\mathbf{IDMU} + \mathbf{MOXU}}{\mathbf{2}}$$

where, **KS** - coefficient of personnel competence level in the pharmaceutical industry of the region;

IDMU - share of specialists with scientific degrees working in the industry;

MOXU - share of employees with advanced training.

Based on the above formula, the coefficient of personnel competence level in the pharmaceutical industry of Surkhandarya region was determined.

$$\mathbf{KS} = \frac{\mathbf{0,40} + \mathbf{0,60}}{\mathbf{2}} = \mathbf{0,50}$$

The calculated value (KS=0.50) indicates that the human resource potential in the pharmaceutical sector in Surkhandarya region is at an average level. From this, we can conclude that the existing human resource base is sufficient to carry out technological processes. However, it is necessary to increase the number of specialists with scientific degrees for innovative development and creation of new products.

At the next stage, the Pharmaceutical Innovation Activity Index (FIFI) was calculated based on an expert-weighted approach, taking into account that not all components have the same importance in the innovation process, and the results are presented in Table 5.

Table 5. Evaluation indicators of the pharmaceutical innovation activity index of Surkhandarya region

№	Indicator name	Indicator symbol	Indicator value	Expert survey results	Expert survey analysis
1	Research activity	IRT	0,406	0,35	The largest share is given to research because it is the basis of innovation.
2	Technological update	ITY	0,416	0,30	Technological innovation drives innovation into production.
3	Product update rate	MYT	0,425	0,20	Product innovation reflects the result of innovation.
4	Human resources	KS	0,50	0,15	Human resources are a supporting but important factor.

The following formula was used to calculate the pharmaceutical innovation activity index:

$$\mathbf{FIFI = \omega_1 \cdot IRT + \omega_2 \cdot ITY + \omega_3 \cdot MYT + \omega_4 \cdot KS}$$

where, $\boldsymbol{\omega_1, \omega_2, \omega_3, \omega_4}$ – are the weights of the IRT IYT, MYT and KS indicators, (Here, the weight coefficients are normalized, and their sum is equal to 1. That is, $\omega_1 + \omega_2 + \omega_3 + \omega_4 = 1$)

Based on all the above calculation processes, the pharmaceutical innovation activity index of Surkhandarya region was determined.

$$\mathbf{FIFI = 0,35 \cdot 0,406 + 0,30 \cdot 0,416 + 0,20 \cdot 0,425 + 0,15 \cdot 0,50 = 0,426}$$

Based on the results of scientific research, taking into account that the pharmaceutical innovation activity index is normalized in the range of 0-1 in the research work, a 5-point integral coefficient scale was proposed for its assessment in the table below (Table 6).

Table 6. Pharmaceutical Innovation Activity Index Integral Coefficient Scale

№	Innovation activity level and index range	Content interpretation	Recommendations and suggestions
1	Very high $0.80 < \text{FIFI} \leq 1.00$	The industry operates on the basis of high technology; Scientific research centers are active; there is a large portfolio of clinical trials; innovative products are export-oriented; human resources potential is very high.	Establish a global pharmaceutical cluster or technopark; enter the international patenting market; create new platforms in the field of biological and gene therapy; further enhance scientific research activities;
2	Good $0.60 < \text{FIFI} \leq 0.80$	Innovative production is active; technologies are modern; innovative products have a high market share; scientific potential is well-	Development of new generation biotechnological products; expansion of international cooperation; bringing the level of digitalization to 80–100%;

		developed; enterprises are competitive.	expansion of export directions.
3	Medium (developing) $0.40 < \text{FIFI} \leq 0.60$	Innovation processes are formed, but not developing intensively; technological innovation is average; market share of new products is insufficient; scientific personnel potential is satisfactory.	Increase the share of research spending (at least 3–5%); increase the number of clinical trials; diversify the product portfolio; organize in-depth biotechnology and pharm-engineering training for employees.
4	Low $0.20 < \text{FIFI} \leq 0.40$	The necessary infrastructure for innovative growth is available, but not actively functioning; patenting activity is low; the share of new products is very low.	Develop a phased plan for technological modernization; initiate cooperation with local scientific institutions; introduce at least 1–2 production lines that meet international quality and safety standards.
5	Very low $0.00 \leq \text{FIFI} \leq 0.20$	There are almost no innovative processes in the industry; Scientific research activities are absent or very weak; technologically outdated production prevails; product diversity is low.	Establishing a minimum number of scientific research units in the region; attracting state/grant programs for the modernization of fixed assets; involving employees in basic training courses.

According to calculations, the Pharmaceutical Innovation Activity Index (FIFI), determined based on a weighted approach, was 0.426 for Surkhandarya region.

4. Conclusion

This result indicates that the innovative activity of the pharmaceutical industry in the region is at an average level. Innovation processes are mainly based on product modernization and human resources, and research activity and technological innovation are not sufficiently developed. Based on the results of the study, we can make the following recommendations to increase innovative activity in the pharmaceutical industry in Surkhandarya region: establish a center for studying costs for innovative research or allocate grants to existing enterprises; organize modernization processes for compliance with international quality and safety standards of production processes; expand opportunities for participation in international clinical trials; organize training and consultations on the formation of patents; develop (if available) training programs in pharmaceutical engineering and biotechnology in order to increase the human resources capacity in the industry.

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