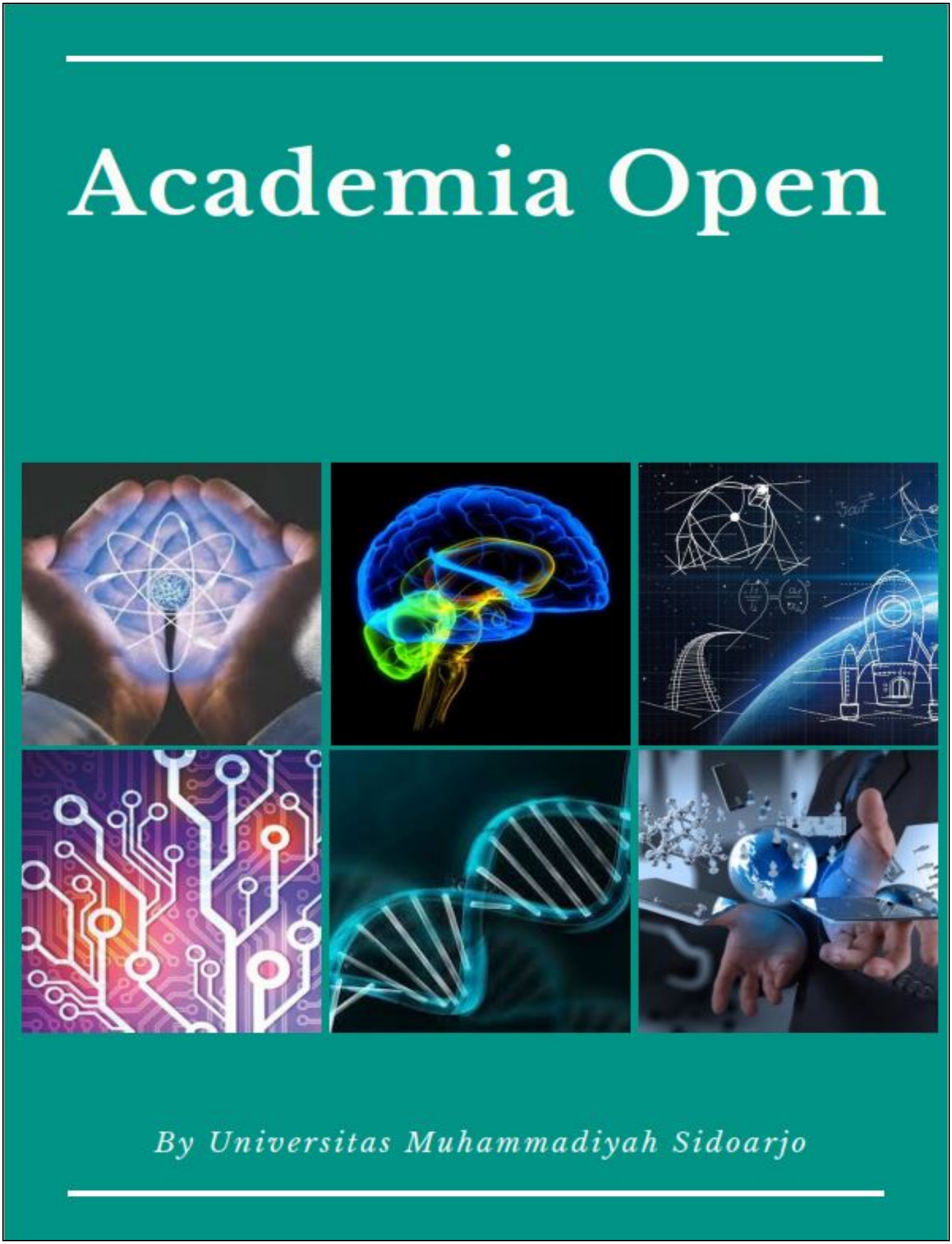
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Forecasting Industrial Growth Using Multi-Stage Regression and Elasticity Analysis

Peramalan Pertumbuhan Industri Menggunakan Regresi Multi-Tahap dan Analisis Elastisitas

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Abstract

General Background: Forecasting the development of industrial enterprises is crucial for strategic planning and sustainable growth. **Specific Background:** Existing models employ mathematical statistics, economic-mathematical modeling, and regression analysis to predict key performance indicators. **Knowledge Gap:** However, there remains limited integration of multi-stage regression methods and elasticity analysis in forecasting industrial output over long-term periods. **Aims:** This study aims to construct a multifactorial forecasting model using multiple regression and correlation functions to estimate the gross product volume of industrial enterprises in Andijan region from 2024 to 2030. **Results:** The model, based on historical data from 2010–2023, achieved a high coefficient of determination (R = 0.962) and an acceptable forecast error (2–8%). Elasticity coefficients indicate consistent growth in production efficiency, despite fluctuations in capital fund efficiency. **Novelty:** The use of multi-stage regression and elasticity-based adjustments, combined with statistical extrapolation, offers a more accurate and regionally contextualized forecast of industrial performance. **Implications:** The findings support targeted strategic planning by highlighting district-level disparities and recommending policy measures such as resource reallocation, entrepreneurship development, and production modernization to ensure sustainable industrial growth through 2030.

Highlights:

1. High accuracy forecast using regression with low error range.
2. Elasticity analysis improves long-term industrial predictions.
3. Informs strategic planning for regional enterprise growth.

Keywords: industrial forecasting, multiple regression, elasticity coefficient, production modeling, economic extrapolation

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Introduction

When forecasting the development of the industrial sector, it is necessary to answer the following questions:

•How will scientific and technological development affect the development of the industry during the forecast period;

•what is the growth rate and the level of product output;

•what will be the need of the industrial sector for resources (production, raw materials, labor, etc.);

•what will be the cost efficiency of the development of an industrial enterprise in the national economic complex.

The impact of scientific and technological development on the development of the industrial sphere affects the change in the parameters of labor, cost-effectiveness, energy efficiency, and so on.

To find an answer to the second question, it is necessary to calculate and substantiate several hypotheses of growth rates and levels of production. At comparable prices for each option, the volume of the gross product of the industry, the volume of production of basic types of products in the form of cash is determined.

When forecasting the needs of an industrial enterprise for various resources, it is necessary to take into account the main trends of scientific and technological development, as well as hypotheses of production levels and growth rates.

Accordingly, the needs of the industry in terms of raw materials, energy, fixed production assets, manpower, etc. are calculated [1,2].

When forecasting the effectiveness of the development of the industrial enterprise in the national economy, it is necessary to rely on the forecast of scientific and technological development, the hypothesis of production levels and growth rates, and the forecast of the demand for various resources.

At this stage, it is necessary to substantiate the change in factors that will ensure the increase in production efficiency during the forecast period.

Such factors are considered to be the most complete use of means of labor, which is manifested by a decrease in indicators requiring a lot of funds and labor, as well as an increase in labor productivity [3].

In the long-term forecast of industrial development in the region, it is necessary to proceed not only from the existing production capacities, but also from the need to maximize the use of favorable regional conditions for accelerating the growth rate of industry in order to achieve reasonable consumer standards.

For an industrial enterprise, forecasts for 10-15 years, that is, really close and taken into account in the planning, are of practical importance [4].

In this study, the period 2010-2023 is taken as the primary period and the equivalent period of 2024-2030 is predicted. It was in the periods under study that a stable process of development of an industrial enterprise took place and is still taking place [5,6].

Various methods are used to forecast the development of industrial enterprise - mathematical statistics, economic and mathematical modeling, technical and economic calculations, system-structural analysis, apparatus of production functions, methods of extrapolation and expert estimation, etc. In practice, more than 100 types of high-performance forecasting methods are now used. All these methods are used not in isolation, but in a harmonious state in order to provide the most correct solution to the problem [7].

The forecast analysis of the prospects for the development of industrial enterprise in the region is carried out in the following directions [8-11]:

•statistical extrapolation and forecasting of the development indicators of the industry with the growth of the forecast period up to 2030 based on production functions;

•use modern modeling and expert analysis methods to improve the accuracy and reliability of forecasts;

•Determination of the role and place of forecast data in the overall scheme of development management and optimization of integrated statistical planning of an industrial enterprise.

Methods

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In constructing models for forecasting industrial enterprise parameters based on the application of multiple-quantity regression methods, the correct processing of empirical statistical data, their comparison, and the exclusion of autocorrelations from dynamic series is very important.

The use of multiple-quantity regression methods in forecasting the parameters of an industrial enterprise involves conducting an initial prediction of independent regression values. Variables in models are usually selected based on in-depth studies of the fields under study, as well as professional knowledge. A multi-stage regression method can also be used for these purposes.

A multifactorial industrial enterprise forecasting model can typically be written as follows [12,13]:

$$y = a_0 + \sum_{i=1}^{n} a_i x_i + \varepsilon_i \qquad (1)$$

Figure 1.

Here it is an involuntary variable that can represent the parameters of the following industrial enterprise: output per worker, asset efficiency, profitability, etc.;

— independent variables that may be evidence on which various factors in industrial models depend on the predicted indicator-;

is a free term describing the tendency of a non-free variable;

is random.

The reliability of statistical indicators is checked by testing the so-called null hypothesis, that is, the probabilistic estimation of the consistency of an actual value of a given indicator obtained from the model in a given sample with the hypothesis that its value in the general set is equal to zero. When testing the nullity hypothesis, a 95% confidence level is accepted, which corresponds to a 5% relevance level [14].

Testing the statistical reliability of a large number of correlation coefficients is performed using the **F-criterion**. At the same time, the hypothesis that there is no complex relationship between function and generality of the factor-arguments considered, i.e., that ***R = 0*** is indeed checked.

In order to study the prospects for the development of industrial enterprise in the region on the basis of statistical extrapolation, the author summarizes the report materials, which describe the dynamics of production in industries with the following main calculated indicators, but depending on the sub-areas that are clearly considered, the indicators can be supplemented and changed [15].

When forecasting the volume of gross product of industrial enterprises according to the report data for 2010-2023, correlation functions for an industrial enterprise were built, with the help of which the forecast of the volume of gross product for 2024-2030 was obtained [16,17].

In the first convergence order, it was assumed that the trends observed during the reporting period will continue during the forecast period due to the inertial strength of economic systems. The projected values obtained were then adjusted for the expected implementation of the plan in 2030, taking into account actual data from 2010-2023.

This made it possible to calculate the relative forecast error (%) using the following formula:

$$e = \frac{V_{prog} - V_{fakt}}{V_{fakt}} 100\% \qquad (2)$$

Figure 2.

The relative error of the forecast values varied in the range of 2-8% that is allowable.

The forecast for industrial enterprise alone is more than 10% higher than actual performance from 2010-2023, which is due to the fact that the plans of industrial enterprises in the above years have been fulfilled with a significant increase.

The coefficient of elasticity in Andijan industrial enterprises (2010-2023) for the entire period is marked by a high of 1, the efficiency of production shows a steady growth. The growth rate of the elastic coefficient of the main production fund is not stable, but the sum of the remaining two coefficients ( ) is increasing and remains almost the same sotx.

The forecast using the correlation function of gross product of industrial enterprises is as follows:

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$$lgy = 1{,}7551 + 0{,}1549\, lgx_1 + 0{,}860 lgx_2 + 0{,}0032 lgx_3 ; \quad (3)$$

$$R = 0.962; \quad S = 0.0567; F = 25.47; \quad \} = 0.0014\%$$

} - the mean error of the approximation and the result of the criterion (Fj = 4.20) are high in the table value (Fnt>Fj).

Figure 3.

Result and Discussion

The main goal of economic development of industrial enterprises of Andijan region in the long term is to significantly increase the material and technical base of industrial enterprises through the full and efficient use of natural and labor resources to ensure high sustainable rates of development of industrial enterprises on the basis of the widespread introduction of achievements of science, technology and innovation, to increase the material and technical base of industrial enterprises through the use of cotton, machine, Providing priority in the light industry and other industries with an increasing volume with specialized products. Businesses across the area's industrial sector play an important role in addressing these challenges. The basic concept of its future optimal development is based on accelerated growth rates.

Year	Volume of services allocated to an entrepreneur	Share of entrepreneurship in GDP %	The share of entrepreneurs in the total number of jobs in the economy of the region %	Number of business entities units	Loans and investments in entrepreneurship mln.sum
2010	1061,2	60,1	75,2	18070	58270,4
2011	1261,3	61,2	76,7	18105	59333,9
2012	1465,2	64,5	78,9	19202	62231,1
2013	1635,9	67,8	78,9	19511	68335,9
2014	1845,1	69,9	79,1	20627	70445,1
2015	2020,2	71,3	79,2	25835	75361,1
2016	2215,4	72,1	80,1	30111	80462,1
2017	2416,9	73,2	81,2	35781	90525,2
2018	2517,8	75,8	82,3	37001	95626,3
2019	2718,9	79,9	84,5	39253	100728,4
2020	2995,1	80,2	85,4	49740	110829,5
2021	3324,9	81,3	86,6	46726	120321,4
2022	3525,8	82,4	87,7	47474	120424,9
2023	3738,9	84,3	88,9	48658	140222,1

Table 1. *Forecast of the main indicators for the development of entrepreneurship in Andijan region*

Y – the gross output of the enterprise;

X_1 - average annual cost of the main industrial enterprise and production assets;

X_2 - average annual number of industrial enterprise and production personnel;

X_3 – material costs (cost of processed raw materials);

X_4 – capital investments to increase fixed production assets.

According to the study, by 2024-2030, the share of entrepreneurship in the GDP of Andijan region will increase by 79.5%, the share of people with total employment in the economy of the region will increase by 86.8%, and the number of entrepreneurship will increase by about 60,658. And the results of this forecast are theoretical proof of the fact that the ambitious task of delivering the share of entrepreneurship in the country's GDP (71.3% in 2023) set by the President of Uzbekistan is in line with real practice. The study took both optimistic and pessimistic options.

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The study selected the following socio-economic indicators of the development of entrepreneurship in Andijan region for 2010-2023: volume of goods and services created in entrepreneurship (y), share of entrepreneurship in GDP (X1), number of business entities (X2), number of employment in entrepreneurship (X3), loans and investments allocated to entrepreneurship (X4),

A more realistic representation of the linear function was demonstrated when the trends in the development of entrepreneurship in the province were analyzed using exponential, level, logarithmic, pointer, and binominal, linear functions. Since the determinant coefficient of the linear function is large, the equation was chosen as a linear function.

The linear regression equation looked like this:

$$Y = 23.8792 + 0.020721X_1 + 0.0012421X_2 + 0.0004321X_3 \quad (4)$$

$R = 0.9704$, dw = 1.83, $F = 9.35$, $S = 19.28$.

Fisher's calculated value ($F_{xis} = 9.35$) compared with the value in the table ($F_j = 4.02$) ($F_{xis} > F_j$)was confirmed to be the wings of the result.

From the above, the time-related regression equations of X_1 , X_2, X_3, X_4 were determined as follows.

$X_1 = 3,4431t + 17,601$, $R^2 = 0,9231$

$X_2 = 2,1041t + 1,8920$, $R^2 = 0,9521$

$X_3 = 0,512t^2 - 5,3128t + 65,289$, $R^2 = 0,8123$

$X_4 = 3548e^{0,1318t} - 23521$, $R^2 = 0,8921$

Figure 4.

Based on the above functions, the forecast values for the corresponding indicators have been determined (Table 2). The optimistic option rests on two main assumptions: Active intervention of the state in the development of entrepreneurship: further deepening of economic reforms in districts and cities, further liberalization of the economy, acceleration of modernization of the economy of the country and regions. It provides for the development and improvement of the structure of business entities of districts and cities with production potential, as well as the development of basic sectors of the economy, large-scale business cooperative relations in districts and cities, the organization, refinancing, rearmament of enterprises with the participation of foreign investment. The pessimistic option provides for the preservation of the old practice of development and placement of business entities, the development of entrepreneurship on the ground without administrative intervention of the state in the development of business entities based on the existing opportunities in their territory (Table 2).

Region	2022	2026		2030	
		Option 1	2 variants	Option 1	2 variants
Dharyan, Andijan region	62,5	73,4	72,9	79,5	85,2
Districts:					
Sulfur	60,2	72,2	71,3	78,4	75,9
Andijan	61,3	72,9	72,5	79,6	79,7
Fisherman	59,3	70,4	70,3	74,4	78,9
Boston (WUZ)	58,4	79,3	70,0	73,5	75,4
Spring Source	56,9	77,9	77,2	76,2	74,9
Jalakuduk	58,1	78,2	77,9	79,0	75,9
Izboksan	59,2	70,4	70,5	72,4	77,8
Ulug'nor	58,2	79,3	70,1	72,9	74,5
Kuriktepa	59,9	70,1	70,2	79,4	75,3
Asaka	60,1	71,3	71,9	78,2	75,4
Marchamat	62,2	73,3	74,0	75,9	77,2
Shakhrikhon	63,4	74,2	74,9	76,9	78,3
Pakhtaabad	62,1	73,3	72,9	74,9	76,4
Khujaabad	60,3	72,4	73,2	79,2	76,2
Household	59,2	70,5	71,1	75,6	78,9
Andijan city.	63,4	75,5	76,9	86,8	82,9

Table 2. *Forecast (%) by the share of business entities in GDP in districts and cities of Andijan region*

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Prognosis

2024	64,5	76,1	75,2	79,9	81,9
2025	65,0	77,8	76,3	80,1	82,8
2026	65,5	79,2	78,2	82,3	83,2
2027	70,2	80,1	79,3	84,1	84,5
2028	75,9	84,3	80,1	83,2	86,2
2029	80,9	85,4	82,3	84,1	87,1
2030	81,9	87,9	83,9	83,2	86,2

Table 3.

These indicators predict that the share of business entities in GDP will increase by 79.2% in 2026 and 87.9% in 2030.

In his opinion, it is advisable to implement the first option in the development of entrepreneurship.

The optimistic option outlined the accelerated development of the business sector in the region in 2010-2023 and the implementation of the following structural changes in the future (2023).

1. Continuation of the gradual implementation of programs and projects for the development of priority areas of entrepreneurship, based on the general reform of the state;

2. Achieving more full use of resources by business entities, establishing joint ventures, further improving the competitive environment between large and small producers;

3. Increasing the competitiveness of their products through technical re-equipment of business entities and the introduction of new technologies, attracting and retraining qualified specialists;

4. Improving the territorial and network structure of business entities;

5. Use of advanced forms of organization and management of production in business entities;

6. Implementation of investment projects to be covered in a short time.

Structural change and modernization of economic sectors in the region will ensure a qualitative shift in the economy. 2022-2026. It is planned to gradually increase the share of small businesses to 14-15 percent in industry, 99.0 percent in agriculture, 75.5 percent in paid services, 15 percent in exports, 36-38 percent in construction.

According to the results of the study, acceleration of innovative processes in business, industrial enterprises depends on the activities of research institutions, universities and other organizations dealing with this issue. In addition, it is desirable to follow the following principles in order to introduce a completely new approach to the development of innovation activities in this area.

For the production of competitive products, the creation of new means for the development of innovative activities, the development of methods of indirect stimulation of investment activities, and comprehensive support of business entities and increase their cost-effectiveness:

According to the estimates, the implementation of an optimistic option for the development of business entities allows:

a. First of all, it is necessary to eliminate obstacles to the development of entrepreneurship on the basis of ensuring the implementation of all the incentives and benefits provided by the legislation;

b. second, to support and further expand this important priority of reform and to seek new resources;

c. and thirdly, industrial enterprises with future production and export-quality products. It is necessary to achieve a leading position in the economy;

d. fourthly, entrepreneurship needs to achieve a modern technical and technological base that works efficiently and intensively. It is necessary to develop market infrastructure by means of service services - special centers, leasing companies;

e. fifthly, it is necessary to pay serious attention to the further development and strengthening of entrepreneurs in the industrial sphere, to fill the domestic and foreign markets with industrial quality products.

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f. Acceleration of the formation of a market, market infrastructure at the expense of the development of business entities, with harmonization of the interests of all regions and cities;

g. rational use of natural and economic opportunities, domestic reserves and factors of economic growth;

h. increase production efficiency;

i. location of divisions, branches of large national and foreign companies for the purpose of development;

j. capacity to create jobs;

k. Increase of income and social protection of entrepreneurs through accelerated development;

l. Orientation to the production of quality and export consumer goods in industry.

Conclusion

Differentiated strategic approach aimed at further development of entrepreneurship on the basis of regression models and methods in industrial enterprises of Andijan region, elimination of imbalances in the distribution of resources on the ground, more efficient use of natural and economic, separately determined the prospects for the development of each district or city. According to the forecast until 2030, ensuring sustainable business growth largely depends on the net results of structural changes. Practical measures to increase the role of entrepreneurship are the improvement of entrepreneurs, support of enterprises producing export-quality products, modernization and technological re-equipment of production facilities at the expense of domestic and foreign investments, stimulation of increasing the volume of production of competitive products through the creation of new enterprises.

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