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Article

Dynamic Modeling of Sustainable Development of Small Business and Entrepreneurship

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Abstract: Small business and entrepreneurship (SBE) have become essential drivers of economic growth and job creation globally. In Uzbekistan, SBE plays a crucial role in regional economic development, with the Kashkadarya region serving as a case study for this research. Despite its importance, a comprehensive understanding of the dynamic development of SBE, especially regarding long-term trends and forecasts, remains underexplored. This study aims to apply trend modeling techniques to analyze the sustainable development of SBE in Uzbekistan, focusing on key indicators such as production volume, employment, investment, and fixed assets. The findings reveal that the development of SBE in the Kashkadarya region is significantly influenced by investments and the use of fixed assets, while the increase in enterprises and employment enhances its socio-economic impact. Trend models were developed to forecast future trends, indicating a substantial increase in production and employment over the next decade. This research introduces a dynamic modeling approach to the analysis of SBE sustainability, providing novel insights into forecasting regional economic growth. The study suggests that policymakers should prioritize investment incentives and infrastructure modernization to support SBE growth, ensuring long-term sustainability and regional development.

Keywords: econometric model, individual, expert, national economy, region, scientific and technical progress, standard of living, volume of resources.

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1. Introduction

Small business and entrepreneurship (SBE) have become integral components of modern economies, contributing significantly to job creation, innovation, and economic diversification. These sectors not only stimulate local economic growth but also enhance regional development by addressing socio-economic challenges such as unemployment and regional disparities. SBE plays a vital role in shaping the economic landscape of both developed and developing countries, including Uzbekistan. In Uzbekistan, the growth of SBE has been identified as a priority in national economic policy. The focus is to foster sustainable development through investments, job creation, and the expansion of productive capacities. The role of SBE in the Kashkadarya region, a region known for its potential in entrepreneurship, offers valuable insights into the broader economic trends of the country. This article explores how SBE dynamics in the region can be assessed through trend modeling, which examines critical indicators like production volume, employment, investment, and fixed assets.

The theoretical framework of this study revolves around trend models and econometric analysis, which are widely used to study economic development. The use of time-series data allows for identifying long-term development patterns, helping to forecast future outcomes. The concept of sustainable economic development is also central to this study, emphasizing how small businesses contribute to long-term economic

resilience by adapting to market shifts and increasing local investments. While extensive research has been conducted on the role of SBE in economic growth, there remains a gap in understanding the long-term dynamics of SBE sustainability, especially in emerging economies like Uzbekistan. Previous studies have examined the role of SBE in job creation and regional development, such as works by Shodiev and Gafurov, but there is limited research applying dynamic trend models to forecast the future trajectory of SBE. This study aims to fill this gap by using advanced econometric tools to predict the future development of SBE in Uzbekistan.

The study employs econometric and trend-based modeling techniques to analyze key indicators of SBE in the Kashkadarya region. By using time-series data from regional statistics, this research develops models to forecast the future development of these indicators. The study expects to find that investments and fixed assets will play a crucial role in driving the growth of small businesses in the region. The results are expected to demonstrate the effectiveness of trend models in predicting SBE dynamics and their contributions to sustainable economic development. Based on these findings, the study will suggest that policymakers prioritize investment incentives and infrastructure development to sustain and enhance the growth of SBE, which will ultimately support broader national economic goals.

Literature Review. The study of small business and entrepreneurship (SBE) has been a central topic in economic research for decades. According to Birch, small enterprises play a fundamental role in job creation and regional development, serving as flexible actors in rapidly changing market environments. Later works by Audretsch and Thurik emphasized the significance of entrepreneurship in promoting innovation, competition, and productivity growth within modern economies [1].

In the field of econometrics, dynamic and trend-based models have been widely applied to assess the sustainability of entrepreneurial activities. Gujarati and Wooldridge highlighted the importance of regression and time-series analysis in identifying long-term development patterns and making reliable forecasts [2]. These methods have proven effective in analyzing macroeconomic and regional-level data, including employment, investment inflows, and output growth.

In the context of Uzbekistan, research on small business and entrepreneurship has been actively expanding. Shodiev and Gafurov analyzed the role of SBE in regional economies, with an emphasis on improving statistical methods and econometric modeling. More recent works, such as Rashidov, have focused on methodological aspects of fostering entrepreneurship in an innovative economy. These studies collectively highlight the need for dynamic modeling tools to capture the complexity of SBE development and to ensure sustainable growth [3].

Based on the reviewed literature, it becomes clear that the application of trend models in analyzing SBE dynamics can provide valuable insights into the long-term trajectories of production output, employment, investment, enterprise creation, and fixed assets. This methodological approach also serves as a bridge between international practices and the specific economic conditions of regions like Qashqadaryo.

2. Materials and Methods

This study employs econometric and trend-based modeling techniques to analyze the sustainable development of small business and entrepreneurship. The methodological framework is built on the use of time series data for key indicators of SBE, including [4]:

a. volume of products produced by small business entities;
b. number of employed persons in SBE;
c. investments directed to the sector;
d. number of enterprises;
e. value of fixed assets.

Trend Modeling. To capture the long-term dynamics of these indicators, trend models were constructed. Linear, quadratic, and exponential functions were tested to determine the best-fit model using statistical criteria such as the coefficient of determination (R^2), the F-statistic, and the significance of regression coefficients. The trend model allows for the

identification of the underlying development trajectory of SBE and provides the basis for forecasting future values [5].

Statistical Validation. The reliability of the models was evaluated using t-tests for individual coefficients and the F-test for overall significance. Multicollinearity and autocorrelation issues were addressed through diagnostic testing. These procedures ensure that the obtained models are statistically robust and suitable for both explanatory and forecasting purposes [6].

By combining trend analysis with a multi-factor regression framework, the methodology enables a comprehensive assessment of the sustainability of small business development, while also identifying the key drivers that influence growth within the sector.

3. Results

Evaluating the development of SBE activities based on trend models allows us to compare the relationships between several set elements. This involves building trend models of time series for these processes, determining quantitative solutions of the relationships between economic phenomena and processes through correlation coefficients, building regression models of economic development, and evaluating and forecasting the development processes of SBE enterprises through trend models [7].

To develop forecast values, it is necessary to first evaluate the previously developed econometric model based on a number of criteria and justify its suitability as the best model for the process under study, and then, based on this model, it will be possible to develop forecast values of the main indicators of the enterprise for the coming years.

In the Kashkadarya region, which is the object of our study, the influence of production factors on the volume of products produced by SBE entities was examined. As a result, forecast values of production factors were determined based on various econometric models, and the corresponding forecast indicators of the volume of products produced by SBE entities were determined [8].

To carry out this analysis, data from the Kashkadarya regional statistics department were used. The number of items, the volume of investments, the number of enterprises, and the value of fixed assets were selected as important factors affecting the volume of products developed by SBE entities. Data for 2000-2024 were used for the analysis.

Table given below was formed according to the data of the Kashkadarya regional statistics department. The data provided, in particular, the volume of products produced by the SBE, investments made in the SBE and the value of fixed assets, are nominal indicators and their direct use will ensure that the conclusions are not justified, see Table 1 [9].

Table 1. Statistical data on the volume of products developed by the SBE in the Kashkadarya region and the factors affecting it (in nominal values).

Years	Volume of products developed by SBEs (billion soums) Y	Number of people employed in SBEs (thousands of people) X1	Investments in SBEs (billion soums) X2	Number of SBE enterprises (in thousands) X3	Value of SBE fixed assets (billion soums) X4
2000	62,7	349,1	8,3	1673,0	502,5
2001	105,0	368,6	14,1	2937,0	647,8
2002	174,7	385,5	15,8	3043,0	791,6
2003	251,5	429,1	21,3	5345,0	821,5
2004	348,0	484,5	43,0	6823,0	1254,2
2005	509,3	545,1	93,7	7921,0	1321,3
2006	837,0	604,0	183,1	8234,0	1662,3

2007	1168,1	641,0	116,1	10332,0	1932,4
2008	1943,4	665,9	365,2	11678,0	2090,6
2009	2727,3	699,8	502,7	12693,0	2190,9
2010	4235,9	726,6	496,5	14503,0	2886,4
2011	5191,3	764,1	537,2	16656,0	4363,2
2012	6240,6	797,9	629,7	16686,0	5560,6
2013	7421,9	835,7	663,3	16087,0	6497,5
2014	9100,5	872,6	859,6	15808,0	7851,7
2015	10900,5	910,0	1121,5	14870,0	9271,1
2016	13449,3	943,9	1560,7	13785,0	11042,2
2017	19124,5	973,9	1609,3	14347,0	14668,1
2018	22595,0	965,8	2074,4	16218,0	17579,7
2019	27473,4	958,1	7458,5	20304,0	20329,4
2020	30254,8	914,1	3676,1	25297,0	24231,2
2021	35467,4	943,7	4459,7	31152,0	28944,8
2022	40398,0	943,8	4303,8	36421,0	32817,5
2023	48397,2	952,4	7945,6	27980,0	39256,7
2024	57267,4	1017,1	15628,0	22452,0	43296,4

Initially, based on the data in Table 1, the volume of products produced by the SBE entities depends on time, that is, we will look at the trend model. In the modeling process, taking into account the fact that the graphical method is a widely used method for selecting a model that corresponds to the laws of development of indicators, it was used, see Figure 1.

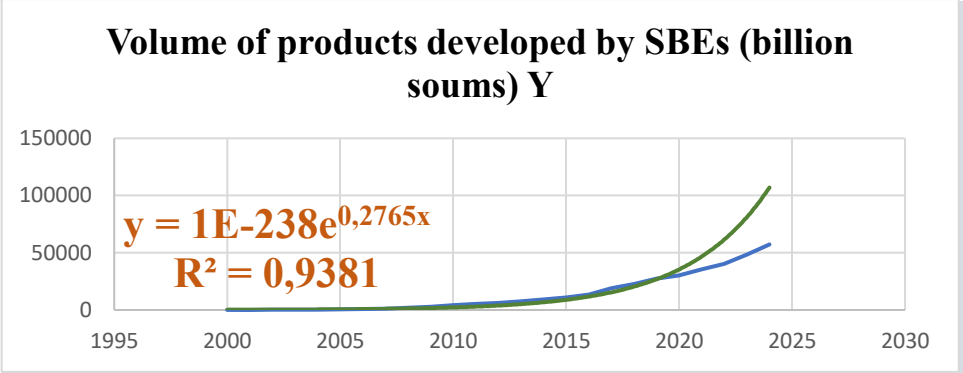


Figure 1. Volume of products produced by IBA entities in Kashkadarya region.

The trend models calculated to forecast the process of change in the volume of products produced by the SBE subjects in the Kashkadarya region are shown in Figure 1. According to the analysis of the results of the resulting trend model, it was found that $R^2 = 0.84$, $F_{calc} = 45.2$. In order to check the adequacy of each coefficient, we would like to touch upon the results of the Student test, according to the results obtained, the t-value of the free limit is equal to $b_0 = 2.55$, $b_1 = -1.55$, $b_2 = 3.74$, and their p-values are 0.02, 0.14 and 0.002, respectively [10].

According to the analysis results, the coefficient b1 does not correspond to the 95% confidence interval. Its confidence interval is 86%. In this case, we will also give the corresponding values of the criteria for the 95% confidence interval. However, taking into account the coefficient of determination and the results of the Fisher criterion, as well as

the graph, we can see that the model fits the general trend, only sharp turns in 2010, 2013 and 2017 violate the trend.

Taking into account the above analysis and the cases identified for all criteria, we decided to use the regression equation of the form $y = 10^{-238} * e^{0,2765t}$ to develop forecast indicators.

The development of forecast values for the number of workers, which is an important factor in product production, allows us to determine the future demand for labor resources and the prospects for ensuring employment of the population. Based on the presented data, we develop a trend model for the number of people employed in the SBE, see Figure 2.

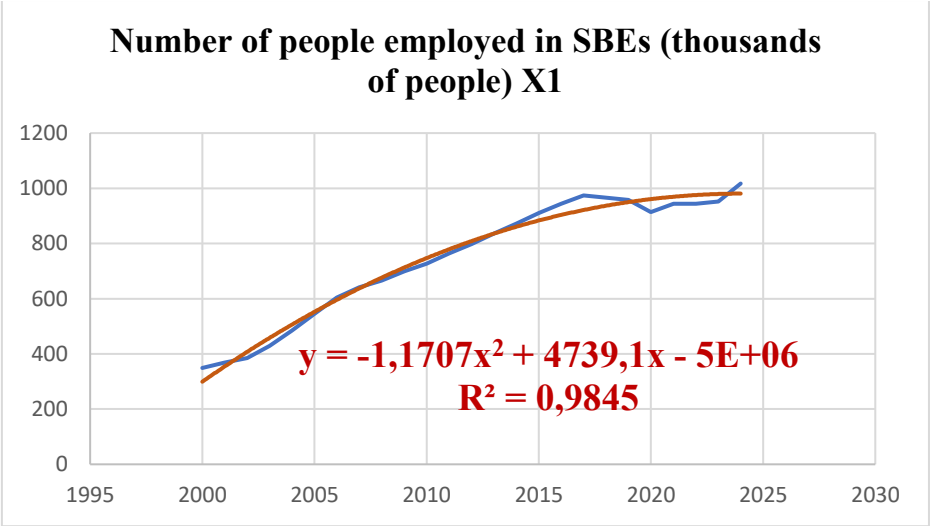


Figure 2. Trend model of the number of workers employed in the SBE activities in the Kashkadarya region.

The trend models calculated to forecast the process of changing the number of workers employed in the SBE activities in the Kashkadarya region are shown in Figure 3.1.2. According to the analysis of the results of the developed trend model, $R^2 = 0.96$, Fcalculated = 118.3. According to the results of the Student test, the t-value of the free limit is equal to $b_0 = 5.31$, and the values of the coefficients $b_1 = 4.64$, $b_2 = -4.43$, $b_3 = 5.28$ are sufficiently high, which leaves no room for resorting to the p-value. However, the tabular values of the criteria do not differ much from those given above, so we did not consider it appropriate to dwell on them separately.

Based on the general results, it was decided to use the regression equation $y = -1.1707*t^2 + 4739.1*t - 5*10^6$ to develop forecast indicators for the number of workers employed in the SBE activities [11].

Taking into account that investments are an important factor in organizing production, increasing efficiency, and expanding production capabilities, we developed trend models for the growth of investments attracted for the development of SBE activities in the Kashkadarya region, see Figure 3.

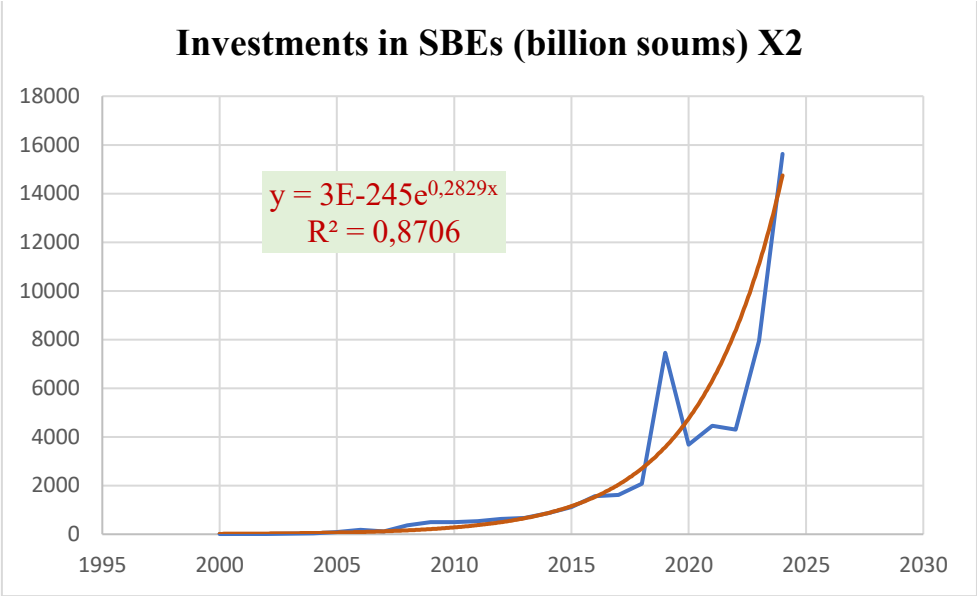


Figure 3. Calculated trend model for investments in the SBE in the Kashkadarya region

From the graph above, we can see that the volume of investments in the SBE does not have a general trend. Therefore, various options were considered and among all types of models, the exponential model was selected, which had the highest coefficient of determination and was selected. According to the results obtained, R^2=0.65, Fcalc=33.4, which is higher than the table indicator. Also, the t-statistics of the coefficients are 8.6 and 5.8, respectively, confirming the adequacy of the determined coefficients [12].

The fact that the results are at the required level according to all the criteria presented gave us the basis for selecting the regression equation in the form of $y = 3E\text{-}245e^{0,2829x}$.

The positive changes in the above indicators require a corresponding increase in the number of small business entities operating in the SBE. Therefore, we aimed to develop forecast indicators for changes in the number of SBE entities in the Kashkadarya region in accordance with their changes.

The calculated trend models for forecasting changes in the number of enterprises engaged in SBE activities in the Kashkadarya region are presented in Figure 4.

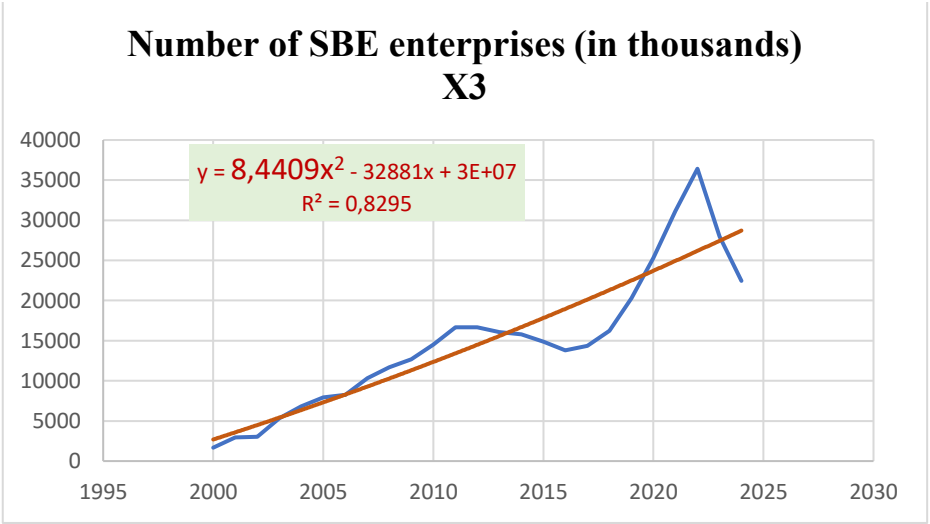


Figure 4. Trend model calculated for the number of SBE enterprises in Kashkadarya region

To justify the adequacy of the developed model, we will consider its results obtained according to its criteria. Despite the slightly low coefficient of determination, i.e. 0.59, all

indicators determined according to the Student and Fisher criteria indicate the adequacy of the model. That is, if Fcalc=7.6, its p-value is 0.005 and indicates that it belongs to the 0.995 percent confidence interval.

The t-value of the free limit according to the Student's test is equal to b0=4.16, b_1=3.51, b_2=-2.71, b_3=2.18, the given values are sufficiently high, which leaves no room for resorting to p-values. Also, during our research, it was found that the reforms carried out in the sector correspond to the changes in the third-order regression equation, and the given model has the highest results.

The fact that the results for all the criteria presented are at the required level led us to select the regression equation of the form $y = 8{,}4409*t^2 - 32881*t + 3*10^7$. The results of the study conducted to forecast the change in the fixed asset value of enterprises engaged in the SBE activity in the Kashkadarya region showed that it does not correspond to any trend model and that their values for the criteria are not at the required level. Therefore, we used the ARIMA (1 1 1) model, which is widely used in time series to develop forecast values. The model was developed using the Gretl program, and the results obtained are presented in Table 2.

Table 2. Model 1: ARIMA, using observations 2000-2024 (T = 25)

	Coefficient	*Std. Error*	*z*	*p-value*	
const	13.2021	8.10550	1.629	0.1034	
phi_1	0.760848	0.190845	3.987	<0.0001	***
theta_1	−0.999997	0.135720	−7.368	<0.0001	***

Mean dependent var	9.342105	S.D. dependent var	77.49406
Mean of innovations	−6.13081	S.D. of innovations	70.37068
R-squared	0.754953	Adjusted R-squared	0.740539
Log-likelihood	−108.193	Akaike criterion	224.8386
Schwarz criterion	228.6164	Hannan-Quinn	225.4780

		Real	*Imaginary*	*Modulus*	*Frequency*
	Root 1	1.3143	0.0000	1.3143	0.0000
	Root 1	1.0000	0.0000	1.0000	0.0000

Standard errors based on Hessian

From the data in Table 2, it is clear that the identified model is adequate in all criteria, except that the z-value of the independent variable in the model is 1.629, which is reasonable at a 90% confidence interval. The representation of the model in the form of a mathematical equation has the following form.

$$\Delta X4_t = 13.2 + 0.76 * \Delta X4_{t-1} - \Delta\varepsilon_{t-1}$$

Using the above model, forecast indicators of the fixed asset value of enterprises engaged in SBE activities until 2030 were developed. In this figure, the actual indicators are marked with a red line, and the values determined on the basis of the model are marked with a blue line, which can be seen that they are located almost close to each other and the random variables have small values. Also, the confidence intervals of the forecast indicators are clearly defined, see Figure 5 [13].

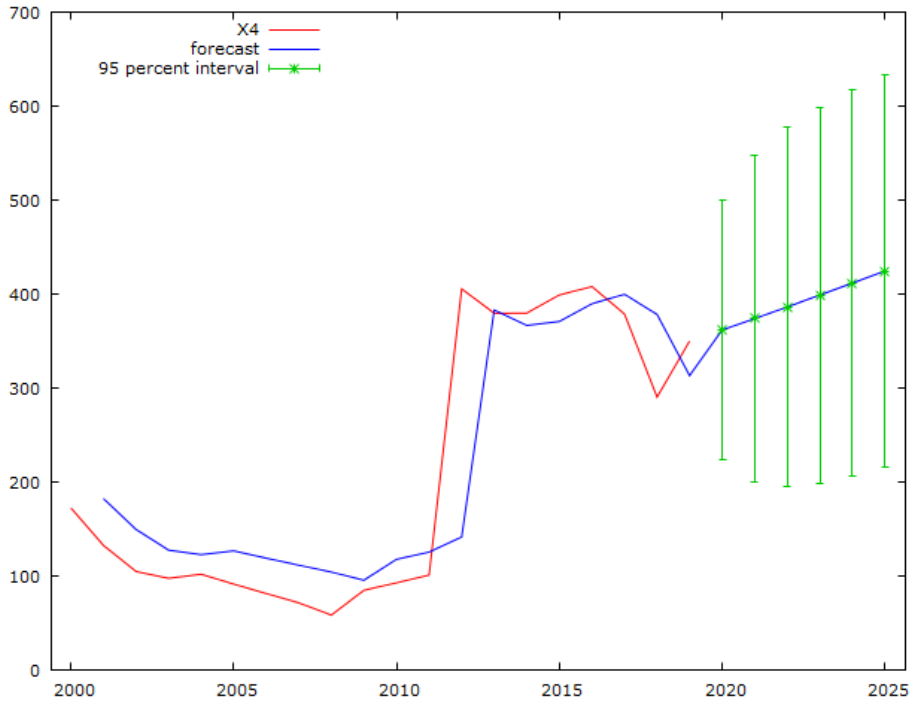


Figure 5. Forecast indicators of the value of the main fund of enterprises engaged in the activity of the SBE.

In order to assess the development trends of the SBE in the Kashkadarya region and develop future indicators for the next period, we have developed forecast values of the indicators listed as its important indicators, namely the volume of production and the main factors affecting it [14]. For this, the trend models calculated above and the ARIMA (1 1 1) models were used, see Table 3.

The results of the developed forecast show that, according to the forecasts obtained from the trend model, the volume of products produced by the subjects of the IBA in the Kashkadarya region will increase by 1.24 times by 2025 compared to 2024, and by 1.79 times by 230. As a result, it was determined that there is a possibility of increasing the volume of products produced by the subjects of the IBA by 10.1% per year according to the current trend, see Table 3.

Table 3. Forecast of the volume of products developed by the SBE in the Kashkadarya region and factors affecting it

Years	Volume of products developed by SBEs (billion soums) Y	Number of people employed in SBEs (thousands of people) X1	Investments in SBEs (billion soums) X2	Number of SBE enterprises (in thousands) X3	Value of SBE fixed assets (billion soums) X4
2024 real	57267,4	1017,1	15628,0	22452,0	43296,4
2025	59257,2	1113,1	18753,6	26942,4	51955,68
2026	64539,3	1317,2	12437,5	30117,8	50599,5
2027	71018,9	1537,5	13854,1	31202,7	55641,0
2028	77803,8	1714,3	15343,8	32287,5	60921,0
2029	84894,0	1957,9	16906,6	33372,4	66439,6
2030	92289,5	2125,9	18542,4	34457,3	72196,8

According to the results of the study, the number of people employed in the SBE will increase by 1.22 times by 2026 compared to 2024, and by 1.07 times by 2030. Since the cubic equation was used to develop the forecast values of this factor, forecast values were developed for the medium term.

The volume of investments in the SBE is projected to increase by 1.30 times by 2026 compared to 2024, and by 2.11 times by 2025, the number of SBE enterprises is projected to increase by 0.93 times by 2026 compared to 2024, and by 1.28 times by 2030. If we look at the model used to forecast the number of SBE subjects here graphically, we can see that the random variables, which are the differences between the indicators determined by the model and the actual indicators, have large values in some time intervals [15].

4. Discussion

It is precisely this situation that occurs at the end of the period taken for analysis, which causes the forecast values to be low in the initial period. Taking this into account, we believe that corrective work should be carried out. A similar problem was also encountered when developing a trend model for the value of fixed assets of the SBE, and considering that no trend model is adequate, it was decided to use ARIMA (1 1 1) models. The results obtained in the process of developing the model and implementing the forecast justify the correctness of this decision. According to the identified forecast indicators, the value of fixed assets of the SBE will increase by 1.07 times by 2026 compared to 2024, and by 1.22 times by 2030.

The study proved that if the current pace of development is maintained, small business and entrepreneurship will make a strong contribution to sustainable economic growth in the near future. At the same time, it is advisable to set as a priority in state policy such areas as stimulating investment flows, modernizing fixed assets and increasing employment [16][17].

5. Conclusion

The study highlights the significant role of small business and entrepreneurship (SBE) in the sustainable economic development of the Kashkadarya region in Uzbekistan. The findings show that key factors such as investments, the modernization of fixed assets, and the expansion of enterprises contribute directly to increased production output, job creation, and regional socio-economic growth. Trend modeling reveals a positive correlation between these indicators and the overall success of SBE, demonstrating the importance of creating an enabling environment for small businesses. The implications of these findings suggest that policymakers should prioritize investment incentives, infrastructure development, and supportive regulations to foster SBE growth. Furthermore, the research calls for additional efforts to improve access to finance and modern technologies for small businesses. For future research, exploring the impact of digital transformation, innovation, and global economic factors on SBE sustainability in Uzbekistan will provide deeper insights into how the sector can continue to thrive and contribute to long-term economic resilience.

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