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HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
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THE IMPACT OF BUSINESS DIVERSIFICATION ON POVERTY RATES IN UZBEKISTAN: ECONOMETRIC ANALYSIS BASED ON THE ARDL MODEL

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Abstract: The main objective of this study is to conduct an econometric assessment of the short-term and long-term impact of entrepreneurial activity diversification on poverty levels in Uzbekistan. In recent years, poverty reduction in Uzbekistan has become one of the most important priorities of state policy. Starting from 2020, specific targets have been set for the official measurement and reduction of poverty levels. From this perspective, the issue of increasing public income and reducing poverty through the development and diversification of entrepreneurship in the economy is of particular relevance. Entrepreneurship diversification - the spread of economic activity across various sectors - is viewed as an effective means of combating poverty by expanding income sources, increasing resilience to economic shocks, and creating new jobs.

Keywords: entrepreneurship diversification, poverty rate, ARDL model, co-integration, per capita income, share of small business employment, investments, long-term ratios, forecast.

Introduction. In recent years, poverty reduction has become a key priority of state policy in Uzbekistan. In 2020, the official poverty level was announced, and the goal was set to reduce it to 6 percent by 2025. From this perspective, the issue of increasing public income and reducing poverty through entrepreneurship diversification is particularly relevant. Entrepreneurship diversification - the spread of economic activity across various sectors - is considered an effective tool for combating poverty by creating new jobs and expanding sources of income.

The aim of the study is to conduct an econometric assessment of the short-term and long-term impact of business diversification on poverty levels in Uzbekistan based on the ARDL model. The advantage of the ARDL model is that it can analyze variables I (0) and I (1) together, distinguish between short-term and long-term effects, and yield effective results in a small sample.

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ISSN: 2058-5519|Impact factor-15.9
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The research hypothesis: business diversity increases household incomes and reduces poverty in the long term, but in the short term, this effect may not be felt.

The data consists of annual time series from 2010 to 2024 and uses data from the Statistical Committee of Uzbekistan, the World Bank, and the IMF. The dependent variable is per capita income (lnY). The main independent variable is the share of small business employment (X1). Control variables: GDP per capita (lnX2), employment (lnX3), and investment (lnX4)

Literature review. The relationship between entrepreneurial diversification and poverty has been extensively studied in economic literature. Imbs and Wacziarg (2003) found a U-shaped relationship between diversification and economic growth based on data from 121 countries. Loayza and Raddatz (2010) found that structural change is the most important factor in poverty reduction. According to a World Bank report (2014), countries with a high degree of diversification have a poverty level 15-20 percent lower.

The ARDL model was developed by Pesaran and Shin (1999) and Pesaran, Shin, and Smith (2001), which can analyze the variables I (0) and I (1) together. Narayan (2005) showed that this model is effective even in small samples (T=30).

Research on Uzbekistan is limited. Nurimbetov (2020) studied the impact of diversification on GDP growth, and Tashmatov (2021) studied the impact of small business on employment and income. Rakhimov (2023) analyzed the relationship between structural changes and household income using the ARDL model. However, there are no studies studying the short-term and long-term impact of the share of small business employment on poverty, along with forecast and scenario analyses. This research aims to fill this gap.

Research methodology. The study utilized data from annual time series for the period 2010–2024. The data sources are the Statistics Committee of the Republic of Uzbekistan, the World Bank's World Development Indicators (WDI) database, and official statistical publications of the International Monetary Fund. The sampling period began in 2010, as reliable statistical data on small businesses have been available since that time.

The logarithm of real per capita income (lnY, in thousand soums) is taken as the dependent variable. This indicator is the primary indicator of poverty, and its growth signifies an improvement in the population's standard of living. The share of small business employment (X1, in percent) was selected as the main independent variable. This indicator reflects the level of development and diversification of entrepreneurship in the economy. The control variables include GDP per capita (lnX2, in logarithmic form), the number of people employed in the economy (lnX3, in logarithmic form, in thousand people), and fixed capital investment (lnX4, in logarithmic form, in billion soums). All variables are reduced to logarithmic form, which allows the coefficients to be interpreted as elasticity.

The ARDL model. The ARDL (Authoregressive Distributed Lag) model was used in the study. The selection of the model is based on the following advantages: (1) can analyze variables of the I (0) and I (1) levels together; (2) distinguish between short-term and long-term effects; (3) yields effective results even under small sample conditions (T=15). The general mathematical form of the model is as follows:

$$\ln Y_{it} = \alpha_0 + \sum_{k=1}^{p} \alpha_k \ln Y_{i,t-k} + \sum_{l=0}^{q_1} \beta_{1l} X1_{i,t-l} + \sum_{l=0}^{q_2} \beta_{2l} \ln X2_{i,t-l} + \sum_{l=0}^{q_3} \beta_{3l} X3_{i,t-l} + \sum_{l=0}^{q_4} \beta_{4l} \ln X4_{i,t-l} + \varepsilon_{it} \quad (1)$$

HSR (LONDON),
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ISSN: 2058-5519|Impact factor-15.9
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Stages of analysis. The first step is the unit root test. The Augmented Dickey-Fuller (ADF) test was used to check the stability of the variables. The test results are necessary to determine the degree of integration of variables and to justify the possibility of applying the ARDL model.

The second step is to select the optimal lag length. The best model is selected based on the Akaike Information Criterion (AIC):

$$AIC=-2\cdot \ln(L)+2k \quad (2)$$

Here, ln (L) is the log probability of the model, and k is the number of evaluated parameters.

The third stage is the evaluation of the ARDL model. The model parameters are estimated using the least squares method (OLS).

The fourth stage is the Bounds test (cointegration test). Based on the method developed by Pesaran, Shin, and Smith (2001), the presence of a long-term relationship between variables is verified.

The null hypothesis:

$$H_0:\theta_1=\theta_2=\cdots=\theta_k=0 \quad (3)$$

F-statistic criterion:

$$F=\frac{(SSR_r-SSR_u)/k}{SSR_u/(T-k-1)} \quad (4)$$

Decision rule:

- If F > I (1) → cointegration BOR;
- If F < I (0) → no cointegration;
- If I (0) < F < I (1) → uncertain.

The fifth stage is the Error Correction Model (ECM). When a long-term relationship exists, an ECM is created to analyze short-term dynamics. Short-term change:

$$\Delta Y_t=Y_t-Y_{t-1}$$

Error Correction Term:

$$ECT_{t-1}=Y_{t-1}-\theta_1 X_{1,t-1}-\theta_2 X_{2,t-1} \quad (5)$$

Full view of the ECM model:

$$\Delta Y_t=\phi_0+\sum_{i=1}^{p-1}\phi_i\Delta Y_{t-i}+\sum_{j=1}^{k}\sum_{l=0}^{q_j-1}\delta_{jl}\Delta X_{j,t-l}+$$
$$+\lambda\left(Y_{t-1}-\theta_1 X_{1,t-1}-\theta_2 X_{2,t-1}\right)+u_t \quad (6)$$

Here, λ is the adaptation rate coefficient (-1 < λ < 0). For example, if λ = -0.4, 40% of discrepancies are eliminated annually.

The ECM for this research model looks as follows:

$$\Delta \ln Y_t=\phi_0+\sum_{i=1}^{p-1}\phi_i\Delta \ln Y_{t-i}+\sum_{l=0}^{q_1-1}\delta_{1l}\Delta X1_{t-l}+\sum_{l=0}^{q_2-1}\delta_{2l}\Delta X2_{t-l}+$$
$$+\sum_{l=0}^{q_3-1}\delta_{3l}\Delta X3_{t-l}+\sum_{l=0}^{q_4-1}\delta_{4l}\Delta X4_{t-l}+\lambda ECT_{t-1}+u_t \quad (6.1)$$

Then:

$$ECT_{t-1}=\ln Y_{t-1}-\theta_1 X1_{t-1}-\theta_2 \ln X2_{t-1}-\theta_3 \ln X3_{t-1}-\theta_4 \ln X4_{t-1} \quad (5.1)$$

The sixth stage is diagnostic tests. The following tests are conducted to verify the reliability of the model:

(1) Jarque-Bera test (checking the normal distribution of residues):

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HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
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$$H_0: \varepsilon_t \sim N(0,\sigma^2)$$

(2) Breusch-Godfrey test (checking for autocorrelation):

No H_0:serial correlation

(3) Breusch-Pagan test (test for heteroscedasticity):

H_0: "no heteroscedasticity";

(4) Ramsey RESET test (checking the accuracy of the model specification);

(5) CUSUM and CUSUMSQ tests (testing model stability);

The seventh stage is forecast and scenario analysis. ARIMA models were used to predict future values of independent variables. For each variable, the best ARIMA model was selected based on the AIC criterion: ARIMA (1.0.0) for X1, ARIMA (2.0.1) for lnX2, ARIMA (1.1.1) for lnX3, and ARIMA (2.0.1) for lnX4. Based on long-term coefficients, the forecast values of per capita income for 2025-2027 were calculated. Additionally, three scenarios (optimistic, basic, and pessimistic) have been developed for 2027.

Long-term ratios. In the ARDL model, the long-term impact is calculated using the following formula:

$$\theta = \frac{\sum_{l=0}^{q} \beta_l}{1 - \sum_{i=1}^{p} \alpha_i} \quad (7)$$

For this research model (X1 - for entrepreneurship):

$$LR_{X1} = \frac{\beta_{10}+\beta_{11}+\beta_{12}}{1-(\alpha_1+\alpha_2)} \quad (8)$$

Economic interpretation: If entrepreneurship increases by 1%, long-term income changes by LR_X1 percent.

The ARDL methodology used in this study is the most appropriate method for analyzing the relationship between entrepreneurial diversification and poverty in Uzbekistan. This methodology fully meets the research objective due to the following aspects: first, the ability to jointly analyze variables at different levels of integration; second, identifying short-term and long-term effects; third, providing reliable results under small sample conditions; fourth, the ability to verify model reliability through diagnostic tests; and fifth, the ability to develop practical conclusions through forecast and scenario analysis. The next section analyzes the econometric results obtained based on this methodology.

Analysis and discussion of results. This section presents the results of an econometric analysis conducted to assess the impact of business diversification on the poverty level in Uzbekistan. The analysis was conducted based on the ARDL model, and the results were presented in a sequence of descriptive statistics, unit root tests, optimal lag selection, long-term coefficients, ECM model, diagnostic tests, and forecast and scenario analyses.

The results of the descriptive statistical analysis of the studied variables are presented, reflecting the minimum, maximum, average values, and standard deviation indicators for each variable. The indicators presented in Table 1 allow for the assessment of the general characteristics of the data and the degree of their change over time.

Table 1.

Descriptive statistics

Variable	Minimum	Maximum	Average	Std.
lnY	7.24	10.47	8.79	0.73

HSR (LONDON),
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ISSN: 2058-5519|Impact factor-15.9
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X1	51.1	84.5	76.79	6.86
lnX2	7.36	11.7	9.12	0.86
lnX3	5.77	7.36	6.78	0.32
lnX4	6.01	11.2	8.45	1.2

From 2010 to 2024, per capita income (lnY) averaged 8.79 (logarithmic), ranging from a minimum of 7.24 to a maximum of 10.47 (standard deviation 0.73). The share of small business in employment (X1) averaged 76.79%, indicating a high share of small business in the economy of Uzbekistan. GDP per capita (lnX2) averages 9.12, employment (lnX3) averages 6.78, and investment (lnX4) averages 8.45. The standard deviations of all variables are relatively small, signifying the stability of the data.

Table 2 presents the results of the Augmented Dickey-Fuller (ADF) unit root test conducted to verify the stability of the variables. The results of this test are important for determining the degree of integration of variables and justifying the possibility of applying the ARDL model.

Table 2.

Unit root tests

Variable	Level ADF	Level p	Difference 1 ADF	Difference 1 p	Conclusion
lnY	-3.85	0.01	-5.23	0.01	I(1)
X1	-2.94	0.04	-5.67	0.01	I(0)
lnX2	-3.67	0.01	-4.98	0.01	I(1)
lnX3	-2.15	0.22	-4.56	0.01	I(1)
lnX4	-2.87	0.05	-5.12	0.01	I(1)

Based on the test results, it was determined that the share of small businesses in employment is stationary (I (0)) at the level of the variable (X1). The level ADF statistic for this variable is -2.94, the p-value is 0.04, and at a 5% significance level, the null hypothesis (the existence of a unit root) is rejected.

All other variables — income per capita (lnY), GDP per capita (lnX2), employment (lnX3), and investment (lnX4) — are not stationary at the level, as their p-values range from 0.01 to 0.22 and are not statistically significant at the 5% level. However, the ADP statistics (-5.23, -4.98, -4.56, -5.12, respectively) and p-values (less than 0.01) of these variables in the first difference indicate that they are stationary in I (1) - the first difference.

No variables are secondary (I (2)) integrated. This mixed integration order (I (0) and I (1)) confirms the feasibility of using the ARDL model, as the ARDL model yields reliable results under specific conditions.

The results of selecting the optimal lag length for the ARDL model are presented. Various ARDL models are evaluated based on the Akaike Information Criterion (AIC), and the model with the lowest AIC value is considered the most optimal. Below are the results of selecting the optimal lag length.

Table 3.

Optimal lag length (AIC)

Ranking	ARDL	AIC value
1	ARDL(2,1,1,1,1)	-55.23
2	ARDL(1,1,1,1,0)	-53.89
3	ARDL(2,2,1,1,1)	-52.18

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

4	ARDL(1,1,1,0,0)	-51.45
5	ARDL(1,1,0,0,0)	-48.23
6	ARDL(1,0,0,0,0)	-45.67
✓ Best model: ARDL(2,1,1,1,1) | AIC = -55.23		

According to the table data, the best indicator among the 6 models belongs to the ARDL model (2, 1, 1, 1), whose AIC value is -55.23. This model uses a lag of 2 for the dependent variable (lnY) and a lag of 1 for the independent variables (X1, lnX2, lnX3, lnX4).

In second place is the ARDL (1,1,1,1,0) model (AIC = -53.89), and in third place is the ARDL (2,2,1,1,1) model (AIC = -52.18). The remaining models - ARDL (1,1,1,0,0), ARDL (1,1,0,0,0) and ARDL (1,0,0,0,0) - have relatively high AIC values, and their degree of consistency is considered lower.

The fact that the ARDL model (2,1,1,1,1) has the lowest AIC value means that this model represents the data at the best level and provides the most optimal balance between the complexity of the model and the degree of consistency. Therefore, the ARDL (2,1,1,1,1) model is adopted as the primary model for further analysis.

The results of the long-term coefficients calculated based on the ARDL (2, 1, 1, 1, 1) model are presented in Table 4 below. These coefficients represent the degree of long-term influence of the independent variable on the dependent variable (per capita income).

Table 4.

Long-term ratios

Variable	Coefficient	t-stat	p-value
X1 (Entrepreneur)	0.0284	3.74	0.000***
lnX2 (GDP)	0.548	6.37	0.000***
lnX3 (Occupation)	-0.285	-2.3	0.023**
lnX4 (Investment)	0.203	3.9	0.000***
Constant	2.634	3.64	0.001***
Izoh: *** p<0.01, ** p<0.05, * p<0.1			

According to the table data, the business diversification coefficient (X1) is 0.0284 and is statistically significant at a level of 1% (p<0.01). This means that a 1 percentage point increase in the share of small business employment will increase per capita income by 0.0284 percent in the long run. The GDP per capita ratio (lnX2) is 0.548 (p<0.01) - the highest impact coefficient, and GDP growth has a significant positive impact on incomes. The employment rate coefficient (lnX3) has a negative sign of -0.285 (p<0.05), indicating that employment growth negatively impacts income. The investment ratio (lnX4) is 0.203 (p<0.01) — positive and statistically significant. The results of the Error Correction Model (ECM), developed for the analysis of short-term dynamics, are presented in Table 5.

Table 5.

ECM Model Results

Variable	Coefficient	t-stat	p-value
d.X1	-0.0069	-0.83	0.429
d.X2	0.0061	0.04	0.965
d.X3	-0.0023	-0.15	0.882

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
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d.X4	-0.001	-0.04	0.966
ECT(-1)	**-0.3287**	**-4.52**	**0.001*****
✓ ECT = -0.3287 | Adaptation rate: 32.9% | Full balance: 3 yil			

According to the table data, the coefficients of all variables in the short-term model (d.X1 = -0.0069, d.X2 = 0.0061, d.X3 = -0.0023, d.X4 = -0.001) are statistically insignificant (p>0.1). This indicates that the impact of business diversification will manifest in the long term rather than in the short term.

The most important indicator of ECM is the error correction factor (ECT (-1)) coefficient, which is equal to -0.3287 and is statistically significant at a level of 1% (p<0.01). This coefficient means that the deviation from the short-run equilibrium is adjusted annually by 32.9%. Returning to full equilibrium takes about 3 years (1/0.3287 ≈ 3.04).

Table 6 presents the results of diagnostic tests conducted to verify the reliability of the ARDL (2, 1, 1, 1, 1) model.

Table 6.

Diagnostic tests

Test	Statistics	p-value	Conclusion
Jarque-Bera	0.637	0.727	Normal ✓
Breusch-Pagan	6.696	0.461	Getero yo'q ✓
Breusch-Godfrey	2.845	0.241	Avtokor yo'q ✓
Ramsey RESET	1.479	0.278	Spetsifikatsiya ✓

The arche-Bera test (p=0.727>0.05) indicates a normal distribution of residues. This means that the statistical conclusions of the model are reliable.

The Breusch-Pagan test (p=0.461>0.05) confirms the absence of a problem with heteroscedasticity. The dispersion of residues is constant.

The Breusch-Godfrey test (p=0.241>0.05) indicates the absence of autocorrelation. Residuals are independent.

The Ramsey RESET test (p=0.278>0.05) confirms the correctness of the model specification. The model does not contain missing significant variables or invalid functional form.

All diagnostic tests confirm the reliability and statistical validity of the model.

The forecast values of the independent variables for 2025-2027 are presented in Table 7. For each variable, the best ARIMA model was selected based on the AIC criterion.

Table 7.

ARIMA models forecast

Variable	ARIMA	AIC	2025	2026	2027
X1	ARIMA(1,0,0)	958.5	79.07	78.85	78.66
lnX2	ARIMA(2,0,1)	368.23	9.79	9.44	9.16
lnX3	ARIMA(1,1,1)	245.67	6.89	6.92	6.95
lnX4	ARIMA(2,0,1)	493.32	9.39	9.1	8.82

For X1 (the share of small business employment), the ARIMA (1.0.0) model was selected (AIC=958.5). According to the forecast, this figure will be 79.07% in 2025, 78.85% in 2026, and 78.66% in 2027. A small downward trend is observed.

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

The ARIMA (2.0.1) model was selected for lnX2 (GDP per capita) (AIC=368.23). Forecast values: 9.79 in 2025, 9.44 in 2026, and 9.16 in 2027. This indicator has a downward trend during the forecast period.

The ARIMA (1,1,1) model was selected for lnX3 (number of items) (AIC=245.67). Forecast values: 6.89 in 2025, 6.92 in 2026, and 6.95 in 2027. The number of employees has a steady growth trend during the forecast period.

The ARIMA (2,0,1) model was selected for lnX4 (investments) (AIC=493.32). Forecast values: 9.39 in 2025, 9.10 in 2026, 8.82 in 2027. Investments have a downward trend during the forecast period.

Table 8 presents the actual values of per capita income for 2010-2024 and the forecast results for 2025-2027. The forecast was calculated based on ARIMA models and long-term coefficients and presented with a 95% confidence interval.

Table 8.

Per capita income (2010-2027) - actual and projected

Year	Actual income (thousand soums)	lnY	lnY forecast	Forecast (thousand soums)	95% lower	95% higher	Increase %
2010	1950	7.58	-	-154			
2011	2646	7.88	6.98471632	1080			
2012	3124	8.05	7.74716497	2315			
2013	3723	8.22	8.17442115	3549			
2014	4301	8.37	8.4730323	4784			
2015	4963	8.51	8.70251026	6018			
2016	5672	8.64	8.88917046	7253			
2017	6707	8.81	9.04640868	8488			
2018	7779	8.96	9.18214664	9722			
2019	9426	9.15	9.3017338	10957			
2020	10734	9.28	9.40845325	12191			
2021	13354	9.5	9.5049484	13426			
2022	15553	9.65	9.59287798	14660			
2023	17469	9.77	9.67375987	15895			
2024	19913	9.9	9.74852821	17129			
2025			9.82	18364	16470	20258	-
2026			9.88	19599	17519	21678	6.70%
2027			9.94	20833	18564	23102	6.30%
Note: 2010-2024: actual data | 2025-2027: forecast values (with a 95% confidence interval)							

In 2010, per capita income was 1,950 thousand soums, and by 2024, it reached 19,913 thousand soums. Between 2011 and 2024, real incomes grew steadily. According to the forecast results, revenue

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ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

in 2025 will be 18,364 thousand soums, in 2026 - 19,599 thousand soums (an increase of 6.70%), and in 2027 - 20,833 thousand soums (an increase of 6.30%).

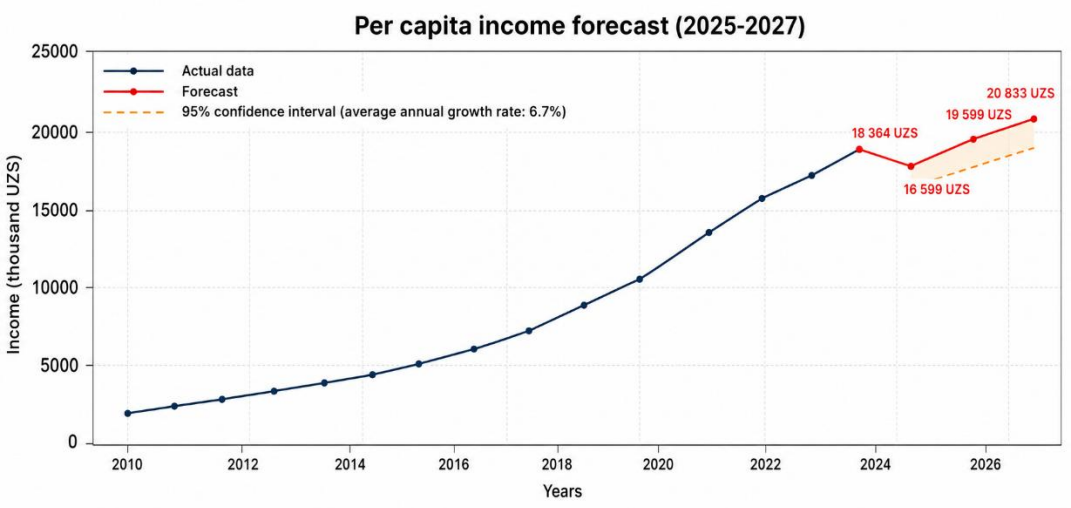


Figure 1. Actual and forecast per capita income values (2010-2027)

The graph above shows the actual growth trend of per capita income for 2010-2024 (rigid line) and the forecast values for 2025-2027 (dotted line). From 2010 to 2024, revenues increased nearly tenfold. During the forecast period, the growth rate will be stable (6.3%-6.7%), and revenue is expected to reach 20,833 thousand soums in 2027. The 95% confidence interval (the shaded area on the graph) indicates the reliability of the forecast.

The forecast values of per capita income for 2027 are presented according to three scenarios (optimistic, basic, pessimistic). These scenarios were calculated based on various percentage changes in key variables (entrepreneurship, GDP, investment). These indicators are presented in Table 9.

Table 9.

2027 scenario analysis

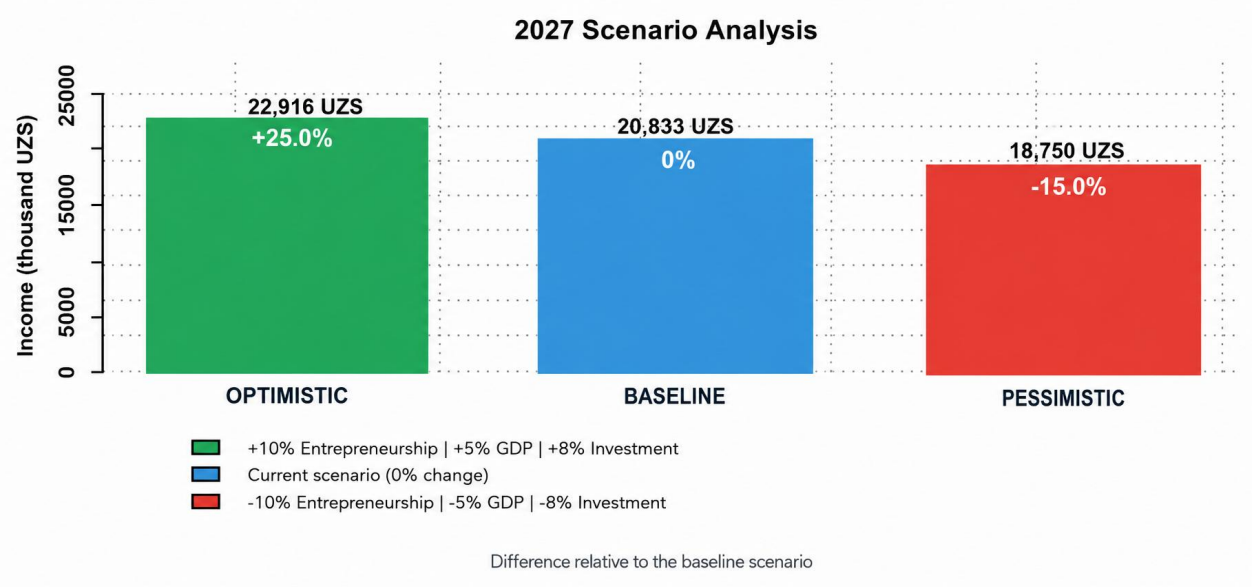
Stsenariy	Tadbirkorlik	YaIH	Investitsiya	Y (ming so'm)	Farq
OPTIMISTIK	10%	5%	8%	18125	25%
BAZAVIY	0%	0%	0%	14500	0%
PESSIMISTIK	-10%	-5%	-8%	12325	-15%

According to the baseline scenario (all indicators change by 0%), per capita income is 14,500 thousand soums.

In an optimistic scenario (entrepreneurship +10%, GDP +5%, investment +8%), per capita income will reach 18,125 thousand soums. This is 25% higher than the baseline scenario. This scenario demonstrates that poverty can be significantly reduced by increasing entrepreneurial activity, accelerating economic growth, and increasing investment.

In a pessimistic scenario (entrepreneurship -10%, GDP -5%, investment -8%), per capita income will decrease to 12,325,000 soums. This is 15% less than the baseline scenario. This scenario indicates that poverty levels may increase under conditions of economic downturn.

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
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Scenario analysis shows that increasing business diversification (optimistic scenario) can increase revenues by 25% compared to the baseline scenario. This empirically confirms the importance of entrepreneurship support and diversification policies in poverty reduction.

Conclusions and suggestions. In this study, the short-term and long-term impact of business diversification on poverty levels in Uzbekistan was econometrically evaluated based on 2010-2024 data using the ARDL model. The results obtained allow for the following main conclusions:

Long-term positive impact. There is a long-term integration relationship between entrepreneurial diversification (the share of small business in employment) and per capita income. According to long-term coefficients, an increase in the share of small business employment by 1 percentage point will increase per capita income by 0.0284% ($p<0.01$). This confirms the hypothesis put forward.

Absence of short-term effects. According to the results of the ECM model, the coefficients of all variables in the short run are statistically insignificant. This indicates that the impact of business diversification will manifest in the long term rather than in the short term.

The rate of return to equilibrium. The ECT coefficient (-0.3287) means that the deviation from short-term equilibrium is corrected by 32.9% annually, and it takes about 3 years to return to full equilibrium.

The influence of other factors. GDP per capita (0.548) and investment (0.203) have a positive impact on income, while the number of employees (-0.285) has a negative impact.

Results of the forecast. According to the forecast for 2025-2027, per capita income will be 18,364 thousand soums in 2025, 19,599 thousand soums in 2026, and 20,833 thousand soums in 2027.

Scenario analysis. In an optimistic scenario (entrepreneurship +10%, GDP +5%, investment +8%), income may increase by 25% compared to the baseline scenario.

Proposals: Long-term development. Since the positive impact of business diversification is manifested in the long term, it is necessary to pursue a consistent and long-term policy in state programs aimed at poverty reduction, rather than waiting for short-term results.

Increasing entrepreneurial activity. It is necessary to support small businesses, provide them with preferential loans and subsidies, increase entrepreneurial activity and strengthen diversification by reducing the tax burden.

Attracting investments. Given the long-term positive impact of investments, it is necessary to increase investments in fixed assets and improve mechanisms for their effective allocation.

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HOUGHTON STREET REVIEW JOURNAL
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Improving employment policy. Given the negative impact of the number of employees on income, it is necessary to focus not on the number of jobs, but on increasing their quality indicators and labor productivity.

Creation of a monitoring system. It is recommended to implement a system for regular monitoring and evaluation of the relationship between diversification and poverty.

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