



## **International Congress on Economics, Management and Business Studies**

Hosted Online from New York, USA

Date: 23<sup>rd</sup> June , 2026

Website: <https://econferencia.com>

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### **DETECTION, CORRECTION, AND FORECASTING OF HETEROSKEDASTICITY IN THE INDUSTRIAL SECTOR: THE CASE OF UZBEKISTAN**

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#### **Abstract**

This scientific article examines the relationship between investments in fixed capital and the gross value added of the industrial sector in the Republic of Uzbekistan using econometric methods. Based on quarterly statistical data for the period 2020–2025, a regression model was constructed. Heteroskedasticity was



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identified using the Breusch–Pagan and White tests and was subsequently corrected through a logarithmic transformation approach. In addition, forecast results for the period 2026–2030 are presented.

**Keywords:** Heteroskedasticity, regression analysis, Breusch–Pagan test, White test, logarithmic transformation, forecasting, industry, investments, Uzbekistan.

### **Introduction**

In econometric modeling, the constancy of the residual variance (homoskedasticity) is one of the fundamental assumptions of the classical regression model. When this assumption is violated, that is, when the variance of the residuals changes across observations, the phenomenon of heteroskedasticity arises. Although the regression coefficients remain unbiased in the presence of heteroskedasticity, their standard errors become distorted, reducing the reliability of statistical inferences.

The purpose of this study is to analyze the relationship between investments and production in the industrial sector of Uzbekistan, identify and correct heteroskedasticity, and develop forecasts for future periods.

### **Data and Methodology**

This study utilizes quarterly statistical data obtained from the official database of the Statistics Agency under the President of the Republic of Uzbekistan (stat.uz). The dataset covers the period from the first quarter of 2020 to the fourth quarter of 2025 and consists of a total of 24 observations.

The following economic indicators were selected for the analysis:

Dependent variable: Gross Value Added of the Industrial Sector (billion UZS)

Independent variable: Volume of Investments in Fixed Capital (billion UZS)



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Table 1. Summary Description of the Data

Quarter	Industrial Gross Value Added (billion UZS)	Investments in Fixed Capital (billion UZS)
2020-Q1	35915,4	1145,0
2020-Q2	73759,4	2588,1
2020-Q3	113035,6	4128,8
2020-Q4	178825,4	6140,3
2021-Q1	41480,7	1213,1
2021-Q2	89870,4	2874,4
...	...	...
2025-Q4	472729,7	15601,5

### Econometric Model

The main hypothesis of this study is that an increase in the volume of investments in fixed capital leads to an increase in the gross value added of the industrial sector. To test this hypothesis, the following linear regression model was constructed:

$$Y_i = \alpha + \beta X_i + \varepsilon_i$$

where:

$Y_i$  – Gross Value Added of the industrial sector in the i-th period;

$X_i$  – Volume of investments in fixed capital in the i-th period;

$\alpha$  – intercept (constant term).



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$\beta$  – regression coefficient.

$\varepsilon_i$  – random error term.

To estimate the model parameters, the **Ordinary Least Squares (OLS)** method was employed. The objective of the OLS method is to minimize the sum of squared residuals:

$$\sum_{i=1}^n (Y_i - \hat{Y}_i)^2 \rightarrow \min$$

As a result of the calculations, the following summary statistics were obtained:

$$\bar{X} = 6065.86$$

$$\bar{Y} = 174636.9$$

$$\sum (X_i - \bar{X})^2 = 295283481.4$$

$$\sum (X_i - \bar{X})(Y_i - \bar{Y}) = 8499720150.2$$

Regression Coefficient:

$$\beta = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sum (X_i - \bar{X})^2} = \frac{8499720150.2}{295283481.4} \approx 28.784$$

Intercept (Constant Term):

$$\alpha = \bar{Y} - \beta \bar{X} = 174636.9 - 28.784 \times 6065.86 \approx 174636.9 - 174595 \approx 41.9$$

As a result, the estimated regression equation is as follows:

$$\hat{Y}_i = 41.9 + 28.784X_i$$

The coefficient of determination ( $R^2 = 0.9855$ ) was estimated at 0.9855. This result indicates that 98.55% of the variation in the gross value added of the industrial sector is explained by changes in the volume of investments in fixed capital. The remaining 1.45% of the variation is attributable to other factors not included in the model.



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To assess the presence of heteroskedasticity in the model residuals, the Breusch–Pagan and White tests were applied.

**Breusch–Pagan Test:** The Breusch–Pagan test is used to examine whether the variance of the regression residuals depends on the independent variable. The test is conducted through the following steps: Asosiy regressiya baholanadi va qoldiqlar  $e_i$  hisoblanadi.

1. An auxiliary regression is estimated by using the squared residuals ( $e_i^2$ ) as the dependent variable.
2. Based on the coefficient of determination  $R_{aux}^2$  obtained from the auxiliary regression, the LM statistic is calculated as follows:

$$LM = n \cdot R_{aux}^2 \sim \chi^2(k)$$

The calculations yielded the following results:

$$R_{aux}^2 = 0.20299$$

$$LM = nR_{aux}^2 = 24 \times 0.20299 = 4.8718$$

$$p = 0.0273$$

$H_0$ : There is no evidence of heteroskedasticity (i.e., the residuals are homoskedastic).)

$H_1$ : The results indicate the presence of heteroskedasticity in the regression model.

p-qiyamat  $p = 0.0273 < 0.05$  bo'lgani uchun  $H_0$  rad etiladi. Demak, Breusch–Pagan testi bo'yicha model qoldiqlarida geteroskedastiklik mavjud.

**White Test:** The White test is another widely used method for detecting heteroskedasticity. Unlike the Breusch–Pagan test, it takes into account the independent variables, their squared terms, and their interaction terms.



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### The calculations yielded the following results:

Auxiliary regression:  $R_{aux}^2 = 0.2525$

White test statistic:  $LM = nR_{aux}^2 = 24 \times 0.2525 = 6.06$

p-value  $p=0.0369$

Since  $p=0.0369 < 0.05$  the White test also confirms the presence of heteroskedasticity.

Table 2. Results of Heteroskedasticity Tests (Initial Model)

Test	Test Statistic	p-value	Conclusion
Breusch–Pagan	4.87	0.0273	Heteroskedasticity is present
White	6.06	0.0369	Heteroskedasticity is present

### Correction of Heteroskedasticity Using Logarithmic Transformation

To address the heteroskedasticity problem, the logarithmic transformation method was applied. The variables were transformed into their natural logarithmic forms as follows:

$$\ln(Y_i) = \alpha' + \beta' \ln(X_i) + \varepsilon'_i$$

The calculations resulted in the following logarithmic regression equation:

$$\ln(\hat{Y}_i) = 0.424 + 0.968 \ln(X_i)$$

The coefficient of determination of the logarithmic model was  $R^2 = 0.9869$  indicating a slight improvement in the explanatory power of the model compared to the initial regression model.

After applying the logarithmic transformation, the heteroskedasticity tests were conducted again:

Breusch–Pagan Test:



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$$R_{aux}^2 = 0.0125$$

$$LM = 24 \times 0.0125 = 0.30$$

$p=0.8419 > 0.05 \rightarrow H_0$  cannot be rejected

White Test:

$$R_{aux}^2 = 0.0321$$

$$LM = 24 \times 0.0321 = 0.77$$

$p=0.4852 > 0.05 \rightarrow H_0$  cannot be rejected

Table 3. Comparison of Heteroskedasticity Test Results Before and After Logarithmic Transformation

Model	Breusch–Pagan p-value	White p-value	Conclusion
Initial Model	0.0273	0.0369	Heteroskedasticity is present
Logarithmic Model	0.8419	0.4852	No evidence of heteroskedasticity (homoskedasticity is satisfied)

The results demonstrate that the logarithmic transformation successfully corrected the heteroskedasticity problem, thereby improving the statistical properties and reliability of the regression model.

### Forecasting Fixed Capital Investment

A time series model was applied to forecast the volume of investments. The estimated trend equation is as follows:

$$\hat{X}_t = a + bt$$



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Using the Ordinary Least Squares (OLS) method, the parameters of the trend equation were estimated, and forecasts of investment volume for the period 2026–2030 were obtained.

### Forecasting the Gross Value Added of the Industrial Sector

By exponentiating the logarithmic regression equation, the forecasting formula was derived as follows:

$$\hat{Y}_i = e^{0.424} X_i^{0.968} \approx 1.528 X_i^{0.968}$$

Table 4. Forecasted Indicators for the Period 2026–2030 (Selected Results)

Period	Investment Volume (billion UZS)	Industrial Gross Value Added (billion UZS)
2026-Q1	10 741,7	310 346,9
2026-Q2	11 488,3	330 912,4
2026-Q3	12 286,9	352 840,6
2026-Q4	13 140,9	376 221,9
2027-Q1	14 054,4	401 152,5
2027-Q2	15 031,4	427 735,2
2027-Q3	16 076,4	456 079,4
2027-Q4	17 194,1	486 301,7
2028-Q1	18 389,6	518 526,7
...	...	...
2030-Q1	31 487,2	866 340,8



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Period	Investment Volume (billion UZS)	Industrial Gross Value Added (billion UZS)
2030-Q2	33 676,9	923 737,4
2030-Q3	36 018,9	984 929,8
2030-Q4	38 510,7	1 050 250,7

According to the forecast results, the gross value added of the industrial sector is expected to increase from 310.3 trillion UZS in the first quarter of 2026 to 1,050.3 trillion UZS by the fourth quarter of 2030. This projected growth indicates the long-term positive impact of investments on industrial development.

### Conclusion

This study analyzed the relationship between investments in fixed capital and the gross value added of the industrial sector in Uzbekistan using econometric methods. The results indicate that an increase of 1 billion UZS in fixed capital investment leads, on average, to an increase of 28.8 billion UZS in industrial gross value added. The Breusch–Pagan test ( $p=0.0273$ ) and the White test ( $p=0.0369$ ) confirmed the presence of heteroskedasticity in the initial regression model. After applying a logarithmic transformation, the assumptions of homoskedasticity were satisfied, as evidenced by the Breusch–Pagan ( $p=0.8419$ ) and White ( $p=0.4852$ ) test results. The logarithmic model demonstrated a high explanatory power ( $R^2 = 0.9869$ ). Furthermore, the forecast results suggest that the gross value added of the industrial sector will increase from approximately 310 trillion UZS in 2026 to 1,050 trillion UZS by 2030. These findings highlight the significant and long-term positive impact of investment on industrial development in Uzbekistan.



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