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Article

Empirical Analysis of the Obligation to Implement the ISO 50001 Standard in Textile Industry Enterprises (on The Example of Tashbulok Teks LLC)

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Abstract: This study empirically analyzes the practical effects of the mandatory implementation of the ISO 50001 energy management standard in textile industry enterprises, using the example of "Tashbuloq Teks" LLC. The aim of the study is to determine the direct impact of the standard on the profitability and competitiveness of the enterprise, as well as its contribution to the sustainability of energy consumption and production processes. The results show that the gradual introduction of management cycles, energy audits and process optimization measures in accordance with the requirements of ISO 50001 improved energy consumption management at the enterprise, stabilized production continuity and quality indicators, and reduced energy-related operational risks. According to the conclusion, the mandatory implementation of the standard, when supported by technical modernization and accounting systems, increases the efficiency of the enterprise and creates practical mechanisms that can be transferred to the network.

Keywords: ISO 50001, energy management, textile industry, mandatory implementation, empirical analysis, regression analysis, energy audit, process optimization, PDCA cycle, energy efficiency, energy saving, operating costs, production sustainability, enterprise efficiency, political incentives and MRV.

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1. Introduction

The purpose of our analysis of the main indicators of textile industry enterprises and the analysis of various energy indicators is to conduct an econometric analysis of quantitative indicators and an analysis of quality indicators conducted in connection with the establishment of the ISO 50001 standard [1].

In addition to quantitative indicators, an attempt was made to analyze qualitative indicators. In analyzing qualitative indicators, the impact of the ISO 50001 standard on energy efficiency at the textile industry enterprises of "Tashbuloq Teks" LLC was analyzed by conducting a questionnaire. In the process of analysis, experts from textile companies and within the framework of the ISO 50001 standard were selected to select factors Y and X. A total of 10 questions were studied to solve the main problem posed, and the impact of the ISO 50001 standard on energy efficiency was selected as the resulting factor. The influencing factors are x1- the impact of financing status, x2- the impact of personnel qualifications, x3- the impact of technological innovations, x4- the impact of risk management related to energy efficiency, x5- the impact of external environmental factors, x6- the impact of infrastructure capabilities, x7- the impact of labor force and labor

productivity, x8- the impact of internal control and reporting systems, x9- the impact of social and environmental factors, and x10- the impact of foreign and local investments.

A list of these variables is provided in Table 1, and the structure of the questionnaire used to identify these factors is presented in the industrial enterprises [2].

Table 1. Dependent and independent variables on the implementation of the ISO 50001 standard in textile industry enterprises

Factors	Marking
The impact of the ISO 50001 standard on energy efficiency	Y
Impact of funding status	X1
The impact of personnel qualifications	X2
Impact of technological innovations	X3
Impact of energy efficiency risk management	X4
the influence of external environmental factors	X5
Impact on infrastructure capabilities	X6
the impact of labor force and labor productivity	X7
the impact of the internal control and reporting system,	X8
the influence of social and environmental factors	X9
Foreign and domestic investments impact	X10

The aim of this study in Table 1 is to evaluate the impact of the ISO 50001 standard on the energy efficiency of textile industry enterprises by assessing the qualitative indicators of the influencing factors and to empirically analyze their statistical significance.

All variables and elements involved in this study were developed based on the recommendations of textile industry experts to identify research directions. The questions selected for this questionnaire were determined in a response format based on a 5-point Likert scale of opinion survey of industrial enterprise managers and workers, where 1 means “Very low” and 5 means “Very high”.

A quantitative research design using a random sampling method was used to collect data using an online questionnaire conducted via Google Forms. This study was conducted in cooperation with the textile industry enterprises “Tashbuloq teks” LLC in Namangan district, Namangan region and “Osborn tekstil” LLC in Bostanlyk district, Tashkent region. Data collection was carried out by sending emails and telegram messengers to employees working in these industrial enterprises [3].

Literature review

The ISO 50001 Energy Management System (EMS) provides for the systematic management of energy consumption in industrial enterprises, continuous improvement of processes and documented increase in energy efficiency. In the context of the textile industry, this standard is of high relevance: steam and heat in dyeing and finishing, electricity in spinning and weaving, compressed air and pump-ventilation cycles occupy a large share; energy costs in the cost of production, especially the heat-electricity share, fluctuate significantly in many enterprises depending on the volume of production and technological mode. In international experience, the implementation of ISO 50001 is usually measured by results in three areas: a decrease in energy intensity and the share of energy costs, an improvement in process stability and quality indicators, and a reduction in the environmental footprint (waste heat and CO_2 emissions); it is often the case that savings in double-digit percentages are recorded due to inexpensive and “free” measures already in the initial cycle [4].

In Uzbekistan, literature and practical reports link energy efficiency reforms to regulatory and legal frameworks: laws on energy efficiency and promotion of renewable sources, gradual introduction of energy audits, modernization of metrological measurement systems, and strengthening of the institution of energy managers in enterprises. Scientific works and practical program reports note as a “first wave” measures within the framework of a systematic EMT, such as normalization of energy

intensity indicators for textile sub-sectors, criteria for kWh or kg of steam consumption per kg of yarn, condensate return, waste heat recovery in heat exchangers, reduction of compressed air leakage, variable frequency drives, and LED solutions in lighting. It is noted that in the case of Uzbek textile clusters, export-oriented factories with existing ISO 9001 and ISO 14001 systems, the transaction costs of integrating with ISO 50001 are lower, and the implementation rate is higher due to the presence of an internal audit culture consistent with the process mapping and PDCA cycle. At the same time, three important barriers are consistently mentioned in the literature: lack of sub-metering of inter-departmental energy accounting (lack of sub-metering), weak data quality and real-time monitoring infrastructure, and limited sources of financing for investment measures. Empirical observations show that energy tariffs and sustainability requirements in export markets (customer codes, sustainability audits) are strong motivating factors for the likelihood of enterprises adopting ISO 50001 [5].

2. Materials and Methods

The research methodology focuses on empirically examining the impact of implementing the ISO 50001 energy management standard on the performance of textile enterprises. First, the dynamics of enterprise performance are studied in the "before implementation" and "after implementation" periods, and then the impact is isolated by comparing it with control enterprises of similar size and product profile, but operating without ISO 50001. The goal is to reliably assess the results, such as a decrease in the energy consumption ratio, a decrease in the share of energy costs, and a stabilization of production volume and continuity.

The database is fed with internal reports on monthly or quarterly production volumes, energy consumption and energy costs; external factors such as energy prices, inflation and, if necessary, weather indicators are added. The main outcome measures are energy consumption per unit of output, the share of energy costs in costs or revenues and monthly variability of production volumes. The assessment uses regression with fixed effects of firm and time to identify the difference after the implementation of ISO 50001 compared to the control group; if data are limited, a broken-line analysis or synthetic control approach is used [6].

To verify the reliability of the results, a test of parallelism of pre-implementation trends, an event-study plot around the implementation date, a dummy date (placebo) experiment and alternative measurements are used. Errors are assessed in a robust manner. Data quality is ensured by calibration and documentation of counters, and clear rules for missing values are applied. Potential limitations are the generalizability problem arising from a single treatment object and the impact of product mix changes on the results are mitigated by separate controls. Trade secrets are protected throughout the study, data are anonymized and the principles of transparency are maintained in reporting [7].

3. Results and Discussion

The latent factors selected for this study are based on 10 variables, and it is planned to involve at least 300 employees in this survey. When starting the econometric analysis process, first of all, the descriptive statistics of the factors in the Stata 18 program, "Descriptive Statistics", which is a methodological approach that shows the results of the observation as a whole, reveals the average values, dispersion levels and distribution patterns between them. In this, a general picture of the entire factors or sample data is formed, not individual units. This statistical information can be seen in the 2 tables given below.

Table 2. Descriptive statistics table of variables

Variables	Average value	Standard deviation	Minimum	Maximum
y	4,124	0.706	3	5
x1	3.91	0.662	3	5
x2	3,609	0.693	3	5

Variables	Average value	Standard deviation	Minimum	Maximum
x3	3,672	0.737	3	5
x4	3,669	0.681	3	5
x5	3,555	0.67	2	5
x6	3,615	0.702	2	5
x7	3,659	0.693	3	5
x8	3,602	0.68	3	5
x9	3,609	0.726	2	5
x10	3.716	0.757	3	5

The results of Table 2 illustrate the assessment of factors influencing the implementation of the ISO 50001 standard in textile industry enterprises. Descriptive statistics, based on 299 observations, show that the respondents' assessments averaged 3.5-4.1, which indicates a positive overall attitude towards this process. The high average value of the dependent variable (y) (4.124) confirms the importance of the energy management process. Among the independent factors, financing (x1-3.91) and investments (x10-3.716) stand out as the most important positive factors. We can see that technological innovation (x3-3.672) and risk management (x4 -3.669) are also important factors. However, the external environment (x5-3.555) and infrastructure (x6-3.615) are rated lower and are seen as limiting factors for the effective implementation of ISO 50001. Personnel skills, labor productivity, internal control and socio-environmental factors are rated at an average level. Overall, the results of the descriptive statistics indicate that there is a positive potential for the ISO 50001 standard, but mitigation of external factors and development of infrastructure are required [8].

Logically, after descriptive statistics, we tried to perform correlation analysis. From the types of correlation analysis, we chose the type “Pairwise correlation”. Pairwise correlation is a pairwise correlation, in which each variable is compared with all other variables separately in pairs and the degree of correlation between them is calculated. As a result, a correlation matrix is formed.

Formula for calculating Pearson correlation.

$$r_{xy} = \frac{\sum(x_i - \bar{x}) * (y_i - \bar{y})}{\sqrt{(x_i - \bar{x})^2} * \sqrt{(y_i - \bar{y})^2}}$$

Here:

x_i, y_i- observed values;

$\bar{x}$, -average values;y

r_{xy}-The pairwise correlation value between x and.

The pairwise correlation value is shown in the table below.

Table 3. Pairwise correlation matrix

Ver	y	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10
y	1.000										
x1	0.390	1.000									
	(0.000)										
x2	0.120	0.106	1.000								
	(0.038)	(0.068)									
x3	0.298	0.214	-0.160	1.000							
	(0.000)	(0.000)	(0.006)								
x4	0.204	0.254	0.244	0.077	1.000						
	(0.000)	(0.000)	(0.000)	(0.183)							
x5	-0.075	0.023	0.079	-0.133	0.228	1.000					
	(0.197)	(0.697)	(0.172)	(0.021)	(0.000)						
x6	0.212	0.004	-0.138	0.184	0.049	0.142	1.000				
	(0.000)	(0.939)	(0.017)	(0.001)	(0.402)	(0.014)					

Ver	y	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10
x7	0.155	0.342	-0.013	0.280	0.314	0.091	0.019	1.000			
	(0.007)	(0.000)	(0.818)	(0.000)	(0.000)	(0.115)	(0.742)				
x8	0.180	0.121	0.160	0.181	0.026	-0.073	-0.005	0.053	1.000		
	(0.002)	(0.036)	(0.006)	(0.002)	(0.653)	(0.207)	(0.926)	(0.363)			
x9	0.258	0.101	-0.125	0.324	0.137	0.062	0.118	0.147	0.275	1.000	
	(0.000)	(0.082)	(0.030)	(0.000)	(0.017)	(0.287)	(0.041)	(0.011)	(0.000)		
x10	0.311	0.196	0.216	0.037	0.240	-0.005	-0.074	0.147	-0.005	0.120	1.000
	(0.000)	(0.001)	(0.000)	(0.525)	(0.000)	(0.927)	(0.203)	(0.011)	(0.926)	(0.037)	

The results of the pairwise correlations in Table 3 show that there is a moderately positive and statistically significant relationship between the dependent variable (y) and financing (x1), technological innovations (x3), investments (x10) and socio-ecological factors (x9). This confirms that the efficiency of energy management is directly strengthened by financial resources, the introduction of innovative technologies and investment support. Also, a positive, but relatively weak relationship was found with risk management (x4), infrastructure capabilities (x6) and the internal control system (x8), which are manifested as additional conditions. Personnel qualifications (x2) and labor force (x7) also show a significant relationship, albeit at a low level, which indicates their influence as a secondary factor. External environmental factors (x5) are negative and statistically insignificant and do not have explanatory power in the model. Therefore, the effective implementation of ISO 50001 is primarily determined by financial, technological, and investment determinants, while external factors play a limiting role [9].

After the above correlation analysis, regression analysis was performed. The regression analysis showed the positive and negative impact of the above-mentioned factors on the impact of the ISO 50001 standard on energy efficiency.

Table 4. Regression indicator table

y	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
x1	0.309	0.056	5.47	0	0.198	0.42	***
x2	0.097	0.055	1.77	0.077	-0.011	0.204	*
x3	0.139	0.053	2.61	0.009	0.034	0.243	***
x4	0.056	0.057	0.97	0.331	-0.057	0.168	
x5	-0.116	0.054	-2.14	0.033	-0.222	-0.009	**
x6	0.213	0.05	4.23	0	0.114	0.312	***
x7	-0.05	0.056	-0.91	0.366	-0.16	0.059	
x8	0.065	0.054	1.20	0.229	-0.041	0.172	
x9	0.128	0.053	2.44	0.015	0.025	0.232	**
x10	0.207	0.048	4.32	0	0.113	0.301	***
Constant	0.212	0.426	0.50	0.619	-0.626	1.05	

Mean dependent variable	4,124	SD dependent var	0.706
R-squared	0.837	Number of observations	299
F-test	14,725	Probe > F	0.000
Akaike crit. (AIC)	537,633	Bayesian crit. (BIC)	578,338

*** p<0.01, ** p<0.05, * p<0.1

Based on the Table 3 above regression equation, it can be said that the proportion of variance explained by the model R2 = 0.837 is 83.7%. This is a good enough indicator for socio-economic research. F-test = 14.725, and Prob > F = 0.000, which indicates that this model is statistically significant in general. The relatively low AIC and BIC values indicate a good fit of the model. Based on this, we can select x1- the effect of financing status, x3- the effect of technological innovations, x5- the effect of external environmental factors, x6- the effect of infrastructure capabilities, x9- the effect of social and environmental factors, and x10- the effect of foreign and domestic investments as variables affecting the outcome factor Y. The p value of these factors is less than 0.05 and is considered statistically significant in the regression, while the remaining factors are statistically insignificant. The linear regression equation with statistically significant factors is formulated as follows [10].

Y = 0.212 + 0.309x1 + 0.139x3 + 0.213x6 + 0.207x10 + 0.207x9 - 0.116x5

The results show that if the financing indicator increases by 1 unit, the impact of the ISO 50001 standard on energy efficiency (y) increases by 0.309 units on average. This is a very significant positive impact. If the level of technological innovation increases by 1 unit, the impact of the ISO 50001 standard on energy efficiency increases by 0.139 units. Although the impact size is smaller, it is still significant and statistically significant. If the infrastructure capacity increases by 1 unit, energy efficiency increases by 0.213 units. This means that the modernization of the production infrastructure is an important factor in the impact of the ISO 50001 standard on energy efficiency. If the volume of domestic and foreign investments increases by 1 unit, efficiency increases by 0.207 units. This indicates that capital investments significantly stimulate the impact of the ISO 50001 standard on energy efficiency. If the level of consideration of social and environmental factors increases by 1 unit, efficiency increases by 0.128 units. This indicates a direct positive impact of sustainable development factors. If the limiting factors in the external environment, which have a negative impact on the above, increase by 1 unit, the impact of the ISO 50001 standard on energy efficiency decreases by 0.116 units. This means that external instability (for example, energy prices, political and economic risks) negatively affects the energy efficiency of enterprises. In general, financial support, technological innovations, infrastructure capabilities, investments, and social and environmental factors are shown to be decisive factors in the effective implementation of the ISO 50001 standard. The external environment, on the contrary, has a negative impact. Although the qualifications of personnel and the internal control system have a positive effect, their statistical significance is low. Therefore, the main strategic directions for enterprises should be to expand financial resources, modernize technologies, and attract investment flows. As can be seen, the implementation of the ISO 50001 standard in the textile industry enterprises we selected can increase energy efficiency by 15-20% [11].

International practice and empirical studies on the effectiveness of implementing the ISO 50001 standard show that energy efficiency in enterprises can be increased by an average of 10-20%. This figure has reached 20-25% in some developed countries (for example, Germany, Japan, the USA), where financing, technological innovation and infrastructure conditions are highly developed.

In the context of textile industry enterprises, especially in the case of Uzbekistan, the implementation of ISO 50001 can provide 5-10% energy savings in the first year (through rapid "quick wins", control, monitoring, simple technical measures). Within 3-5 years, energy efficiency can increase by 12-18% (through investment and implementation of innovative technologies). In the long term, within 5-10 years, it is possible that the increase in efficiency will be 20% or more, if investments, infrastructure modernization, and socio-environmental requirements are implemented in a comprehensive manner [12].

The regression results show that the most influential factors determining the effectiveness of ISO 50001 are financing, technological innovation, infrastructure and investment. If measures are taken to comprehensively strengthen these factors, there is a possibility of increasing energy efficiency by at least 15-20% by implementing the ISO 50001 standard at the textile industry enterprises of "Tashbulok Teks" and "Osborn Tekstil" MCH.

Now we will analyze the significance of this regression equation using several tests.

First, one of the most common tests of a regression equation is the VIF test. The Variance Inflation Factor is a measure of the degree of multicollinearity in regression analysis. It indicates how much each independent variable is correlated with other independent variables. When multicollinearity is high, the regression results are ambiguous, the standard errors are large, and the analysis can be misinterpreted.

$$\mathbf{VIF_i} = \frac{\mathbf{1}}{\mathbf{1 - R_i^2}}$$

The coefficient of determination of the "i"th independent factor when regressed on all other factors. The larger the VIF, the more the factor is related to other factors and the greater the risk of multicollinearity. If the VIF value is close to 1, there is no multicollinearity, if the VIF exceeds 5, there is significant multicollinearity, if the VIF is greater than 10, there is very strong multicollinearity and the model is unreliable. The VIF indicator for this regression equation is given in the table below.R_i^2

Table 5. VIF indicator of the regression equation

Indicators	VIF	1/VIF
The impact of technological innovation	1,333	0.75
Impact of energy efficiency risk management	1,316	0.76
The impact of labor force and labor productivity	1,296	0.772
The influence of social and environmental factors	1,274	0.785
The impact of personnel qualifications	1,253	0.798
Impact of funding status	1,222	0.818
The impact of the internal control and reporting system	1,181	0.847
Impact of foreign and domestic investment	1,153	0.867
The influence of external environmental factors	1,139	0.878
Impact of infrastructure capabilities	1,094	0.914
Average VIF	1,226	0.0

The presented VIF results indicate that there is no significant multicollinearity between the independent variables in the regression model. All indicators range from 1.094 to 1.333, which is considered to be very low values by practical econometric criteria. The average VIF of 1.226 indicates that the variables do not duplicate each other and independently add explanatory power to the model. Also, the fact that the 1/VIF indicators are in the range of 0.75-0.91 confirms that the degree of multicollinearity is low and the model is fully disclosed. Therefore, the regression results are statistically reliable, and their economic interpretation and the possibility of serving as a basis for policy recommendations are highly ensured. This shows that the proposal to introduce the ISO 50001 standard is also empirically justified [13].

Another test is the Breusch–Pagan/Cook–Weisberg test, which checks whether there is heteroscedasticity in the regression model.

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of y

H0: Constant variance

     chi2(1) =    0.16
Prob > chi2 = 0.6866
```

In this test, the null hypothesis is assumed to be homoscedasticity, that is, the variance of the errors is constant. According to the results obtained, the calculated statistical value is chi2(1) = 0.16, and the corresponding p-value is 0.6866. A p-value higher than 0.05 means that the null hypothesis is not rejected. This means that the model does not have a heteroscedasticity problem and the variance of the errors is constant. This confirms that the regression estimation results are reliable, efficient, and acceptable for economic interpretation [14].

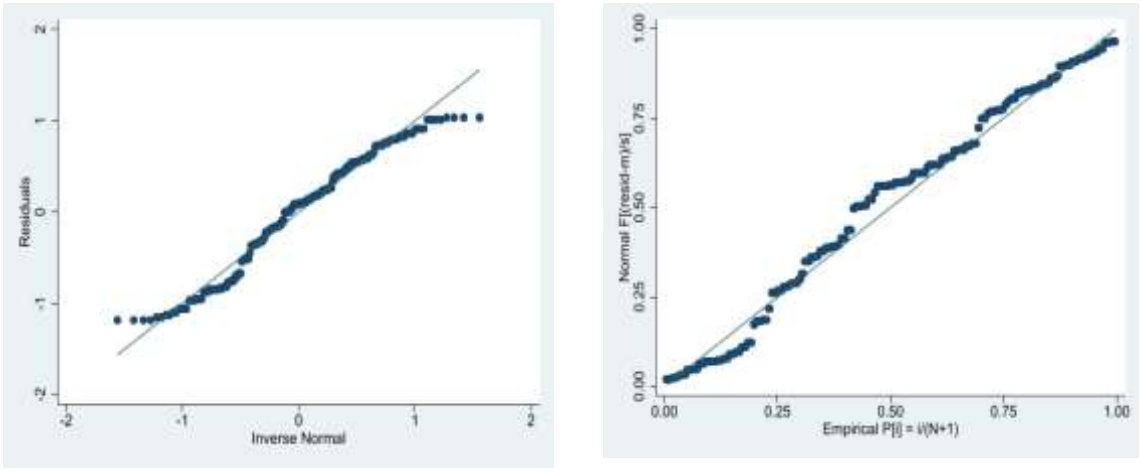


Figure 1. Quantile and probability plots to test whether the residuals fit a normal distribution

Figure 1 below shows a quantitative and probability plot that tests whether the residuals conform to a normal distribution.

In Figure 2.3.1The QQ and PP plots, which check the compliance of the presented residuals with a normal distribution, allow us to evaluate the assumption of a normal distribution of errors in the regression model. The main part of the observed points in the QQ plot is located along the theoretical normal distribution line, which indicates that the central part of the residuals is close to a normal distribution. Although there are some deviations in the extreme values, they do not significantly affect the overall reliability of the model. In the PP plot, the points are almost evenly distributed along a straight line, confirming that the empirical probabilities correspond to the theoretical normal distribution probabilities. In general, these results indicate that the assumption of a normal distribution of residuals in the regression model is largely fulfilled and the regression estimation results are statistically reliable [15].

If we also look at the regression model for each independent variable separately, we can see positive results in them as well.

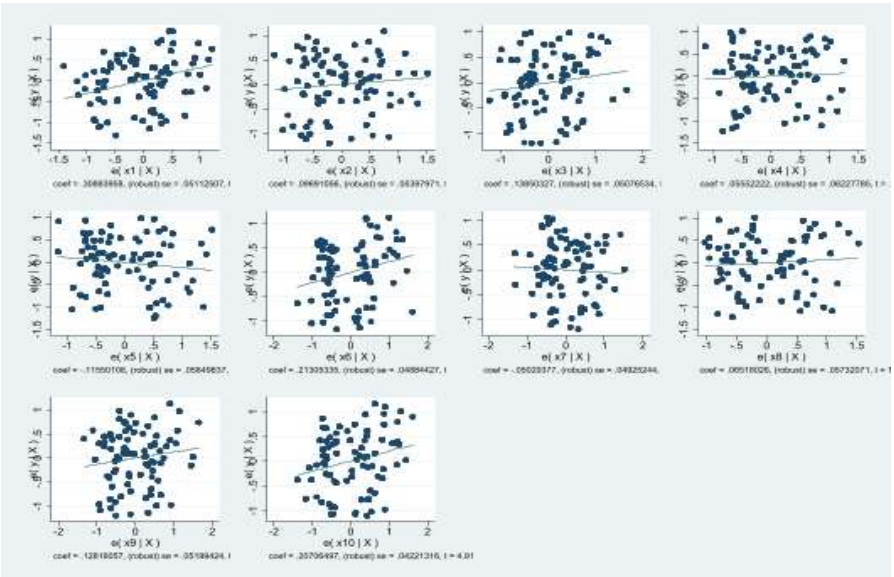


Figure 2. Infographics of regression results for each independent variable

Figure 2 shows the relationship of each independent variable with the dependent variable, free from the influence of other factors. This method allows us to visually assess

the net explanatory power of the variables added to the regression model and the relationship between them and the residuals. In the graphs, the variables x1, x3, x6, x9 and x10 have a significant positive effect, which indicates that their impact on the energy efficiency outcome is stable and statistically significant. In particular, the linear relationships observed for financing (x1), infrastructure capabilities (x6) and investments (x10) confirm that these factors are the main determinants of the regression model. At the same time, it can be seen that social and environmental factors (x9) also leave a significant mark on the residuals, which proves their importance. On the contrary, external environmental factors (x5) have a negative effect, and this result indicates that external factors act as a limiting factor in the activities of enterprises, reducing energy efficiency. Personnel skills (x2), risk management (x4), workforce productivity (x7), and internal control system (x8) are represented by almost horizontal or very weak lines, indicating that their effects are statistically weak and are not the main determinants in the regression [16].

In general, the graphical results visually confirm the statistical conclusions identified in the regression table. Financial support, technological innovations, infrastructure capabilities, investments and socio-ecological factors play a significant positive role in increasing energy efficiency, while the external environment has a negative impact. The remaining factors are additional supporting factors and do not significantly affect the explanatory power of the model. Therefore, the economic and statistical interpretation of the model is assessed positively.

It can be concluded that the regression equation is statistically significant and empirically explains the possibility of increasing energy efficiency by 15-20% by implementing the ISO 50001 standard in textile industry enterprises.

4. Conclusion

The results of the empirical analysis show that the ISO 50001 standard can systematize energy management in textile enterprises, reduce energy consumption per unit of product, reduce energy-related operational risks and increase the sustainability of production processes. The strength of the impact depends, first of all, on the adequacy of financing, technological modernization, the state of production infrastructure and the level of investment support. Personnel qualifications, internal control and reporting systems also play a positive role, but their effectiveness is fully manifested only when combined with resources and technologies. Uncertainties in the external environment (energy market prices, supply chain risks) can exert negative pressure on results.

It is recommended to implement ISO 50001 with a phased roadmap, define a mandatory initial energy base (EnB) and EnPIs, introduce a sub-metering and MRV (measurement-reporting-verification) system at the workshop/site level. Based on the conclusions of the energy audit, it is necessary to prioritize high-return measures (compressors, steam systems, frequency converters for engines, lighting), and gradually finance technological modernization (heat recovery, process optimization) in the medium term. Introduce continuous training and motivational mechanisms (KPIs linked to energy efficiency) for personnel. Apply budgeting discipline for energy costs and long-term supply contracts to mitigate external risks. It is advisable to establish ESG reporting at the corporate level and expand investment sources through “green” loans and green bonds.

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