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Article

Impact of Digitization Potential of Chemical Industry Enterprises on Economic Efficiency

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Abstract: The chemical industry is an important element of the world economy, which has a direct impact on the macroeconomic stability and growing industrial base. The possible opportunities in terms of efficiencies and competitiveness have raised great attention among scholars as more enterprises across industries integrate digital technologies. In this context, the chemical industry of emerging economies (Uzbekistan, etc.) faces the challenges of fully attaining the potential benefits of digital transformation. This switching has been facilitated by the "Uzkimyosanoat" JSC which has a substantial network of chemical production businesses in Uzbekistan. Though the worldwide literature proves the beneficial impact of digital technologies on the efficiency of industrial processes, there is little empirical evidence available in regard to the particular effect the technologies have on the Uzbek chemical industry. This is research paper on relationship between adoption of digital technology and performance of the economy in the chemical industry of Uzbekistan in regard to level of production and net profit. The goal is to find out key predeterminants of digitalization, as well as to assess its impact on the efficiency of a business. Using econometric models, the analysis shows that investments in digital technologies, internet coverage, and labor productivity have a great correlation with increased production volumes and the overall net profit, thus proving the importance of digital transformation as the determinant of economic growth. Therefore, the paper can add to the body of literature with its empirical findings on the topic of digitalization in the chemical industry in the Uzbekistan context where the country has been developing through the processes of economic reform. Its results provide the policymakers and the leaders of the industry in Uzbekistan with viable information that can guide in the creation of strategies that will enhance sustainable growth in digitalization and the enhancement of economic performance of the chemical industry.

Keywords: Digital technologies, output volume, net profit, level of digitization, Investments in digital technologies

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1. Introduction

The high growth rate of the digital economy has transformed the world of industrialization and the digital sector is expected to attain a contribution of $16.5 trillion to the global GDP by 2028. Firms that have high intensity in terms of technology; especially the chemical industry have emerged as focal points of combining digital technologies to enhance productivity, sustainability, and competitive edge. Being one of the core blocks of

the value industrial chain, the chemical industry holds direct impacts on economic strength and innovation in various spheres [1][2].

Recent research highlights the critical role of digitalisation (particularly, artificial intelligence, big-data analytics, the Internet of Things, and automation) in the optimisation of chemical production operations, a reduction in the costs associated with their operations, and increases in profitability. In the industrial sectors, empirical investigations by Shevtsova et al. and Aral et al. have indicated that outstanding correlations between adoption of digital technology and the economic efficiency within firms occurs [3]. However, there remains a strong disparity in the findings of how the potential of digitalization of the chemical enterprise in the developing economy, especially Uzbekistan, can be measured in economic terms. All current literature has mostly concentrated on the advanced economies whereas, there is a vague deficiency of digging into the empirical pool of the post-Soviet states with different digital infrastructures and conventional policies [4].

This gap is closed in the present study, which calculates the effects of the digitization on the performance indicators of the leading chemical enterprises in Uzbekistan, mainly belonging to the system of the state enterprise of "Uzkimyosanoat" JSC [5]. This company oversees over 30 business establishments, which makes it a perfect scenario to evaluate the effectiveness of investment in digital technologies. The use of multivariate regression analyses allows testing the impact of certain variables, such as the level of investments in digital technologies, internet penetration rates, labor productivity, and the general levels of digitalization on key economic indicators, the production output and net profit. The information is represented by national statistical bulletins and the reporting of enterprises that cover 2016-2024 [6].

Current research focuses on the hypothesis that increased digital investment and system improvement to augment infrastructure will have a positive effect on the profitability of companies and the work output. With the help of empirical modeling using STATA-15, the given analysis attempts to support such assumptions and identifying the leading drivers of economy efficiency [7]. Specific care is taken in the existence of multicollinearity and autocorrelation in time-series application, the aim being the attainment of robustness of the model [8].

It is expected that the findings will contribute to policy-relevant ideas, to which governmental actors and industry stakeholders can make their respective decisions. Also, the research produces the forecasting scenarios in terms of polynomials and ARIMA modeling, thus contribute to strategic planning of the 2025-2030 horizon. In the end, the potential of this study is not limited to Uzbekistan and is rather comparative to other developing countries engaged in strategies of improving the heavy industries through digitalization [9].

2. Materials and Methods

The given research analyzes the impact of the digitalization process on the economic efficiency of the enterprises of the chemical industry which are a part of the business complex of JSC Uzbekkimyosanoat in Uzbekistan. It has twofold objectives: the first is to determine the effects of digital technologies on the volume of production and net profit; the second is to determine factors that define the results the most. The econometric model, to be more precise, multiple regression analysis, is selected to measure the dependence between the independent variables, which are the value of new digital technologies, the level of investments into digitalization, internet coverage, labour productivity and the value of fixed assets, and the corresponding dependent variables, i.e. production volume and net profit. The analysis of the data is based on official statistics reports and the records of enterprises in the years 2016-2024. Variance inflation factor (VIF) and the Durbin-Watson test regulate multicollinearity and autocorrelation, individually [10]. Besides, log-transformations are employed to minimize the heteroskedasticity and enhance a fit of the

model; the models are exposed in STATA-15. The results establish the role of digital investment in upholding the performance of the chemical industry and, consequently, establishing approaches that facilitate digital transformation, hence the sustainable growth in the economic niche of Uzbekistan as a part of the national Digital Uzbekistan-2030 plan [11].

3. Results

The chemical industry is an important component of the global economy, and its production volume and net profit indicators have a significant impact on the country's economic stability and development. Econometric analysis of the factors affecting these indicators is important for the development of effective strategies for enterprises and state politicians. Dozens of factors affecting the volume of production, profitability, and the net profit margin of enterprises in the chemical industry have been studied and are being studied by various scientists in many foreign and domestic studies [12].

Studies show that the use of modern production technologies is the main direction of increasing the volume and efficiency of production in the chemical industry. For example, technological upgrades, automated processes, and the introduction of digital control systems can significantly increase production capacity. In general, the studies of scientists such as Shevtsova, Hanna, Natalia Shvets and Maryna Kasatkina on the efficiency and production practices of industrial systems have proven the positive impact of the use of advanced technologies on industrial production [13].

Capital investments and financial support play an important role in increasing production volumes and net profits. Studies on general production function have confirmed the positive impact of capital investments on production. The chemical industry is a capital-intensive industry, requiring significant financial resources to build new plants, modernize existing ones and invest in research and development [14].

Today, the trends of “Industry 4.0” and digitalization are central to increasing the economic efficiency of the chemical industry. Digital technologies, including artificial intelligence (AI), big data, the Internet of Things (IoT), and cloud computing, are enabling the optimization of production processes, cost reduction, and acceleration of innovation [15]

Research shows that investments in digital technologies and the level of digitalization have a direct positive impact on the efficiency of the enterprise. This, in turn, leads to an increase in production volumes and an increase in net profit [16].

Empirical studies using econometric models have been conducted to assess the direct and indirect impact of investments in digital technologies on economic performance. For example, Aral and Sinan, Erik Brynjolfsson found a correlation between IT capabilities and enterprise profitability [17]. Leng, Zhiwu, and Chen, using panel regression models in manufacturing enterprises, proved a positive correlation between the level of digitalization and economic performance [18].

Uzkimyosanoat JSC, which unites 36 chemical enterprises, plays a key role in the development of the chemical industry in Uzbekistan. Therefore, the introduction of digital technologies and their economic performance of enterprises controlled by this company were examined using econometric analysis methods and STATA programs based on the obtained statistical data [19].

An econometric analysis was carried out on the following main factors that the introduction of digital technologies in chemical industry enterprises can affect economic efficiency indicators. (Table 1)

Table 1

The list of the main factors that can affect the indicators of economic efficiency of chemical industry enterprises

Variables	Abbreviation	Name and unit of measurement
Dependent variables	**Y1**	Product production volume (billion soums)
	Y2	Net profit (billion soums)
Independent variables	**X1**	Value of new digital technologies (billion soums)
	X2	Investments in digital technologies
	X3	Digitization rate
	X4	Internet coverage level
Other factors	**X5**	Number of employees
	X6	Labor productivity
	X7	Value of main funds (billion soums)
	X8	Investment volume (billion soums)
	X9	Product price index (%)

Financial variables often exhibit nonlinear changes, so to stabilize the analysis, approximate the relationships between variables to a linear form, and make the regression results more reliable by reducing heteroskedasticity, we use the natural logarithm of the indicators. This ensures the linearity of the model and allows us to explain the elasticity of some factors directly through the coefficients [20].

According to the results of the Pearson correlation of the relationship between variables, the independent variables such as the value of new digital technologies (X1), investments in digital technologies (X2), the level of digitization (3), the level of internet coverage (X4), labor productivity (X6), and the value of fixed assets (X7) all have a very high positive correlation with production volume (from 0.96 to 0.99) [21]. This indicates that factors related to digitization and basic production resources play a decisive role in the growth of production volume (Table 2).

Table 2

Results of the regression between the factors affecting the volume of production

Ln Product_prod	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
LnX1	.703	.101	6.98	.02	.027	.936	**
LnX2	.485	.136	0.63	.005	-.5	.71	***
X4	.031	.004	0.28	.040	-.016	.039	**
X5	.53	0	0.95	.085	.05	.60	
LnX7	-2.165	.795	-2.72	.0013	-2.587	1.257	***
LnX9	.006	.019	0.31	.786	-.074	.086	*
Constant	23.027	6.342	3.63	.068	-4.258	50.313	*

Mean dependent var	10.111	SD dependent var	0.322
R-squared	0.999	Number of obs	9
F-test	223.386	Prob > F	0.004
Akaike crit. (AIC)	-40.479	Bayesian crit. (BIC)	-39.099

*** $p<.01$, ** $p<.05$, * $p<.1$

(Prepared by the author using the STATA-15 program)

These results show that the model selected for the study explains 99.9% of the variation in production volume, indicating a very high fit (R2=0.99). The independent variables (LnX1, LnX2, X4, X5, LnX7, LnX9) explain almost all of the variation in production volume. This confirms the importance of digitalization and infrastructure factors in Uzkimyosanoat JSC [22].

The F-test results also confirmed this (223.386, Prob > F = 0.004), meaning that the model is generally statistically significant ($p < 0.01$), meaning that the variables included together have a significant effect on production volume. The Akaike (AIC: -40.479) and Bayesian (BIC: -39.099) criteria are also negative and small values indicate that the model fits the data well and there is a balance between simplicity and accuracy.

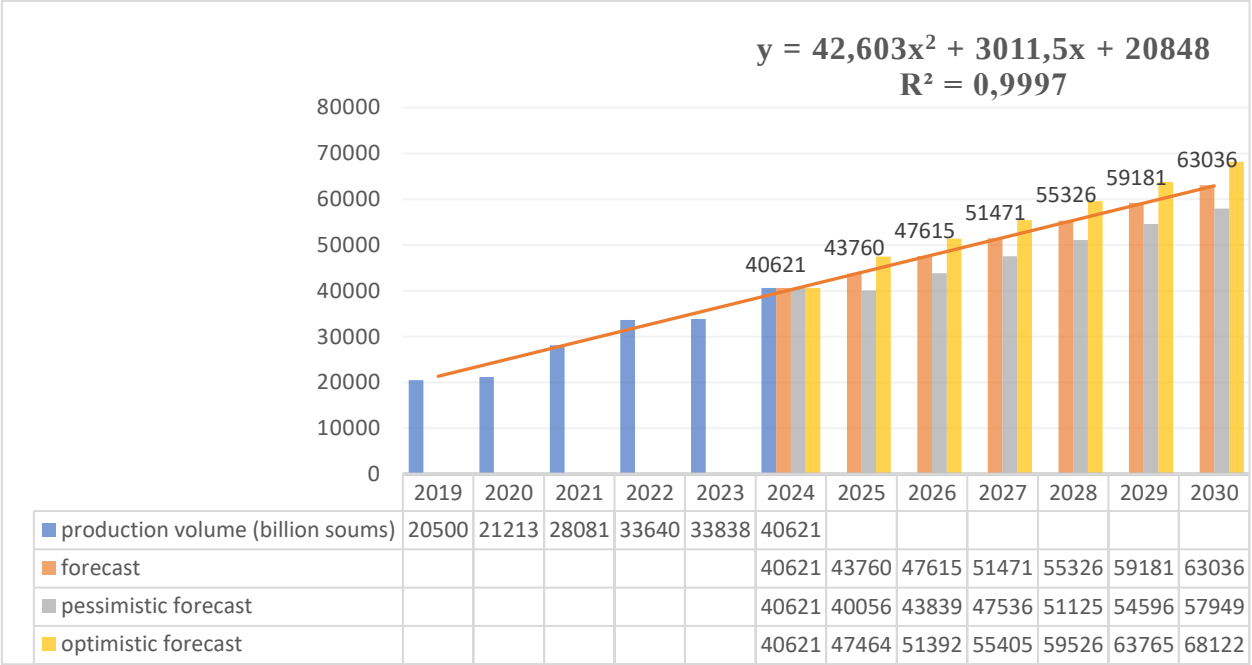
Similarly, the results of the correlation between the factors affecting the net profit of the enterprise show that there are almost similar relationships, for example, the variables LnX1, LnX2, X3, X4, X6, LnX7 have a very high positive correlation with the volume of net profit (from 0.868 to 0.918), which confirms that technological development, efficiency and capital base are the main factors in increasing profits.

It was found that there is a strong negative correlation (-0.578) between the price index of chemical industry products and net profit, which once again confirms that an increase in the price index can reduce net profit (Figure 1).

Now, based on the data obtained, we have constructed a regression equation.

LnProd=23.027+0.703LnX1+0.485LnX2+0.031X4+053X5-2.165LnX7 (1)

Figure 1. Forecast values of production volumes for 2025-2030 years.



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
production volume (billion soums)	20500	21213	28081	33640	33838	40621						
forecast						40621	43760	47615	51471	55326	59181	63036
pessimistic forecast						40621	40056	43839	47536	51125	54596	57949
optimistic forecast						40621	47464	51392	55405	59526	63765	68122

This graph, which reflects the dynamics of the volume of production in the chemical industry for 2019–2030, compares real statistical data, key forecast indicators, as well as forecasts based on optimistic and pessimistic scenarios. The main columns of the graph were formed based on available statistical data for 2019–2024, during which time there was a steady growth in production: if in 2019 the volume of production amounted to 20,500 billion soums, by 2024 this figure reached 40,621 billion soums [23]. Starting from 2025, real statistical data will be replaced by forecast indicators, which are presented in three scenarios - base (main), optimistic and pessimistic. In the basic forecast scenario, the

volume of product production is expected to be 43,760 billion soums in 2025, and by 2030, this indicator is planned to reach 63,036 billion soums. However, since these indicators can change depending on economic and technological factors, the graph includes both pessimistic and optimistic scenarios. In particular, in the case of increased negative factors (pessimistic scenario), it is estimated that the volume of production may reach 57,949 billion soums by 2030, while in optimistic conditions, this indicator is likely to reach 68,122 billion soums.

The graph shows the quadratic regression equation for forecasting production volume:

Y=42,603x2+3011,5x+20848 (2)

The coefficient of determination of the model is R2=0.9997, which indicates that the selected model can explain changes in production volumes with very high accuracy. This indicates that the forecasts made based on the regression model are highly reliable.

Discussion

The above results show that factors related to digitization and basic production resources play a decisive role in the growth of production volume (Figure 2).

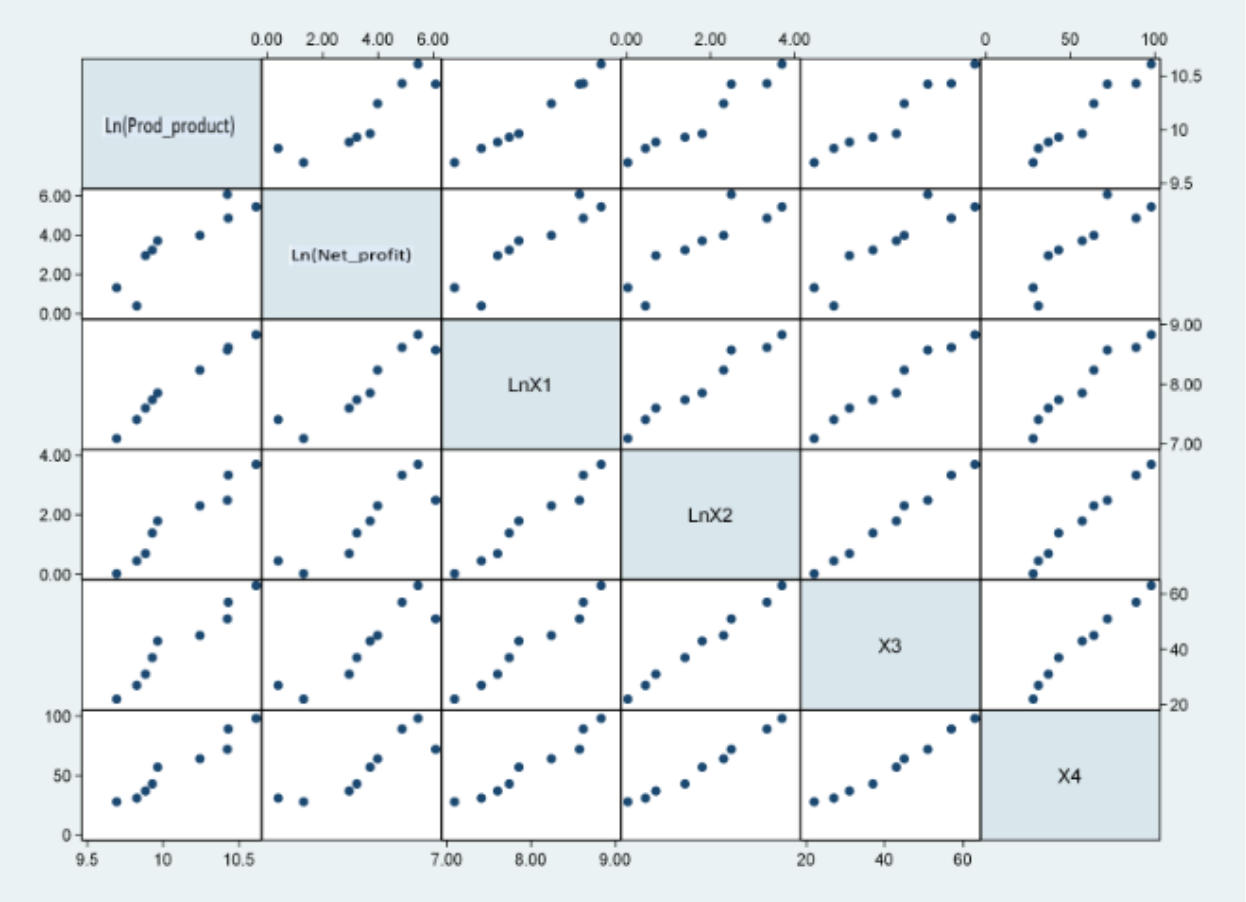


Figure 2. Scatter plot of the relationship between digitalization indicators and production and net profit

However, in the correlation table, it can be seen that there is a very high correlation between some independent variables, for example, 0.979 between LnX1 and LnX2, and 0.989 between X3 and X4. This indicates the presence of a multicollinearity problem. To eliminate this multicollinearity, it is necessary to remove one of the variables with high

VIF values from the model. This is one of the most common and effective methods. If two or more variables have a very high correlation and theoretically represent similar data, only one of them can be left in the model. In our case, there is a very high VIF and correlation between X3 (Digitalization level), LnX2 (Investment in digital technologies) and X4 (Internet coverage level). These three variables reflect the aspect of "digitalization" or "technological development". We significantly reduced the VIF values by leaving only one of them in the model (for example, LnX2 or X3 - the one with the highest correlation or considered more theoretically important). In addition, we eliminated this problem by leaving one of both X5-Number of Employees and X6-Labor Productivity in terms of labor resources.

According to J.M. Wooldridge, the detection and non-inclusion of serial correlation in the idiosyncratic error term in a time series data model leads to incorrect standard errors and ineffective parameter estimates [24]. Therefore, in this study, autocorrelation can be defined as the correlation in a time series that compares past values with future values over a certain time interval. In this study, the Durbin Watson test was used to detect autocorrelation in the residuals in the regression analysis. The null hypothesis of this test is that the data are not serially correlated. If serial correlation is detected in the panel data, then the Feasible Generalized Least Squares (FGLS) estimate is accepted.

The extended Diskey-Filler test was used to test for stationarity. Data over time is considered non-stationary if the average, variance is not constant over a given period, and the value of the covariance between two time periods depends not on the actual time for which the covariance is calculated, but on the lag between time periods. Based on the identified regression equations, we develop forecast values of the enterprise's production volume indicators for 2025-2030 [25].

The ARIMA model was used in this analysis. One of its main advantages is that it takes into account autocorrelation, trend, and random shifts in the structure of the time series. In this analysis, based on the production volume and net profit indicators of chemical industry enterprises in the Republic of Uzbekistan for the period 2016–2024, the ARIMA model is used to determine forecast values for the years 2025–2030. Before building the model, the time series were brought to a stationary state, after which the optimal parameters (selected using the AIC and BIC criteria) were applied. After building the model, forecasts for future periods were formed in the STATA program (Table 3).

Table 3

Trend equations determined by production volume forecast

$Y = 3778{,}4x + 17567$	$R^2 = 0{,}9993$	A linear equation
$Y = 26208e^{0{,}074x}$	$R^2 = 0{,}9979$	The exponential equation
$Y = 32597\ln(x) - 19207$	$R^2 = 0{,}9852$	Logarithmic equation
$Y= 42{,}603x2 + 3011{,}5x + 20848$	$R^2 = 0{,}9997$	A polynomial equation
$Y = 12644x^{0{,}6424}$	$R^2 = 0{,}996$	Level equation

The results obtained were consistent with the results of the digitalization policy model of Uzkimyosanoat JSC, but it is necessary to effectively allocate investments and renew funds. Of the identified trend equations, the most reliable was the multi-level equation, and based on this equation, we calculated the forecast of the production volumes of Uzkimyosanoat JSC for 2025-2030 according to three scenarios.

Conclusion

The model uses logarithmic variables for economic indicators, so their coefficients are interpreted as elasticity. The logarithmic indicator of the value of new digital technologies is statistically highly significant, showing a correlation coefficient of 0.703

(p=0.02<0.05). That is, if the value of new digital technologies increases by 1%, the production volume increases by 0.703% on average. This indicates a strong positive impact of digitalization on production volume. Within the framework of the "Digital Uzbekistan-2030" strategy of Uzbekistan, automated systems, such as IoT, AI-based monitoring systems, are being introduced in the chemical industry. The widespread introduction of new digital technologies at the enterprises of "Uzkimyosanoat" JSC will lead to an increase in production volume and economic efficiency. This confirms that digitalization is the main driving force in increasing the competitiveness of the chemical industry of Uzbekistan.

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