

Improving the Efficiency of Innovation Activity Management at Textile Industry Enterprises: An Econometric Assessment and Digital Transformation-Based Approach

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Abstract: This article examines ways to improve the efficiency of innovation activity management at textile industry enterprises. The purpose of the study is to identify, through econometric methods, the key factors influencing innovation activity and, on the basis of the findings, to develop directions for improving management strategy. The research was carried out using data from "Parvoz Xumo Ravnaq Trans" LLC, applying correlation-regression analysis. The results show that the number of production personnel, staff qualification levels, and expenditures on technological innovation and R&D have a significant and statistically valid effect on output volume. On this basis, a four-stage strategic management mechanism (analysis, planning, implementation, control) is proposed, together with an NLP-AI integration model designed for analyzing patents and scientific literature. The proposed approach makes it possible to improve the quality of innovation management decisions while reducing analysis costs.

Keywords: Innovation activity, textile industry, econometric assessment, regression analysis, human capital, digital transformation, artificial intelligence, NLP, innovation strategy.

Introduction: In recent years, technological renewal in industrial sectors — particularly in textiles — has been accelerating. As enterprises expand in scale and competition intensifies, managing their operations through traditional methods has become increasingly difficult, making the management of innovation activity one of the essential conditions for enterprise development.

Developing innovation activity has been established as one of the priority areas of state policy in the Republic of Uzbekistan. In particular, the President's Decree No. PF-5264 of November 29, 2017 set the task of widely introducing innovations across sectors of the economy, while Decree No. PF-5544 of September 21, 2018 established priorities for supporting research and development work and accelerating technological modernization. The "Digital Uzbekistan – 2030" strategy and related regulatory documents identify the

introduction of ERP systems, artificial intelligence, and digital platforms in industrial enterprises as a priority task.

At the same time, practice shows that innovative development in many textile enterprises remains largely confined to technical and technological renewal, while insufficient attention is paid to managerial innovation and to integrating research findings into production. This creates a need to scientifically substantiate ways of improving the efficiency of innovation activity management.

The purpose of this study is to identify, using the example of a textile industry enterprise, the key factors influencing innovation activity through econometric methods, to quantitatively assess the degree of their influence, and, on the basis of the findings, to develop directions for improving innovation activity management strategy, including mechanisms of digital

transformation.

METHODOLOGY

The study was conducted using data from "Parvoz Xumo Ravnaq Trans" LLC, a textile industry enterprise. Correlation and multiple regression analysis methods were used to determine the relationships among factors influencing the efficiency of innovation activity management.

The choice of a multiple regression model reflects the fact that innovation activity is shaped simultaneously by several factors and therefore cannot be explained through a single indicator alone. The following factors were included in the analysis: the number of employees engaged in production, the number of management personnel, the number of employees with higher and specialized secondary education, the share of employees who have undergone qualification training, expenditures directed toward technological innovation, and expenditures on research and development (R&D). Output volume and the enterprise's balance-sheet profit were used as resulting indicators.

To determine the elasticity between the factors and the resulting indicator, a logarithmic regression model was applied:

$$\ln Y = a + b \cdot \ln X$$

where Y is the resulting indicator (output volume or balance-sheet profit), X is the factor indicator, b is the elasticity coefficient, and a is the constant term. The statistical significance of the model parameters was assessed using Student's (t) criterion, and the overall quality of the model was evaluated through the coefficient of determination (R^2).

In the second stage of the study, based on the econometric results obtained, a strategic management mechanism was developed consisting of four functional blocks: analysis, planning, implementation, and control. In the third stage, directions for digital transformation were proposed, in particular a five-layer integration model designed to analyze patents and scientific literature using natural language processing (NLP) and artificial intelligence; its effectiveness was evaluated comparatively against the traditional (manual) method of analysis.

RESULTS

According to the correlation analysis performed, indicators related to human capital at the enterprise have a considerable influence on output volume. Specifically, a strong positive correlation was found between the number of production personnel and output volume ($r = 0.94$), while an even stronger

correlation was observed for employees with specialized secondary education ($r = 0.96$). A significant correlation was also found between the number of management personnel and output volume ($r = 0.92$). At the same time, the mutual correlation among the factors themselves was also high, indicating the need to account for multicollinearity when constructing the regression model in the subsequent stage.

According to the results of the logarithmic regression analysis, a 1 percent increase in the number of employees with higher education raises output volume by an average of 0.88 percent ($R^2 = 0.91$), while a 1 percent increase in the number of employees with specialized secondary education raises it by 0.95 percent ($R^2 = 0.93$). The elasticity coefficients with respect to the number of management personnel and production personnel were 0.91 and 0.84, respectively. The t-statistics of all coefficients exceeded the critical value, confirming their statistical reliability. The fact that the elasticity coefficients are below one indicates that output volume is inelastic relative to these factors — that is, output increases at a slower rate than the growth of the corresponding resources.

The relationship between staff qualification training and the enterprise's balance-sheet profit was assessed separately: $F = 8.52 + 0.18M$ ($R^2 = 0.57$). The results show that each additional employee who has undergone qualification training leads to an average increase in the enterprise's balance-sheet profit of 0.18 billion soums (180 million soums). The relatively low coefficient of determination (0.57) confirms that qualification training is not the sole factor shaping profit, although it does have a positive effect.

To assess the impact of technological innovation and R&D expenditures on output volume, a two-factor logarithmic model was applied:

$$\ln Y = 2.11 + 0.73 \cdot \ln(X_{\text{innovation}}) + 0.21 \cdot \ln(X_{\text{R\&D}}),$$

$$R^2 = 0.94$$

The t-statistics of all coefficients exceeded 2, confirming their statistical significance. A 1 percent increase in expenditures directed toward technological innovation raises output volume by 0.73 percent, while a 1 percent increase in R&D expenditures raises it by 0.21 percent. The model explains 94 percent of the variation in the resulting indicator. The fact that the effect of technological innovation exceeds that of R&D indicates that the practical component of innovation activity dominates at the enterprise, while the integration of research findings into production remains insufficient. The main econometric results are summarized in Table 1.

Table 1

Indicator	Coefficient (b)	t-statistic	R ²
Number of employees with higher education	0.88	8.00	0.91
Number of employees with specialized secondary education	0.95	10.56	0.93
Number of management personnel	0.91	7.00	0.89
Number of production personnel	0.84	7.00	0.88
Share of employees with qualification training (effect on balance-sheet profit)	0.18	2.57	0.57
Technological innovation expenditures	0.73	3.84	0.94
R&D expenditures	0.21	2.63	0.94

Source: prepared by the author based on data from "Parvoz Xumo Ravnaq Trans" LLC.

Based on the econometric results obtained, a strategic innovation management mechanism was developed consisting of four functional blocks — analysis (A), planning (B), implementation (C), and control (D). Within this mechanism, the enterprise's internal and external environment is assessed, alternative innovation strategy options are formulated, the most suitable direction is selected, and its implementation is monitored. The recommended core mechanisms include technological modernization, human capital development, financing of innovation activity,

organizational cooperation, and export-oriented innovation marketing.

In the area of digital transformation, a five-layer integration model was proposed for analyzing patents and scientific literature based on NLP and artificial intelligence. It is recommended that the model be implemented in three stages (infrastructure and data — 1–2 months; pilot testing — 2–3 months; full deployment — 1–2 months; totaling 4–7 months). The results of a comparative assessment against traditional manual analysis are presented in Table 2.

Table 2

Indicator	Traditional (manual) analysis	NLP-AI model	Change
Monthly expert analysis time, hours	120–180	18–30	–80...85%
Completeness of identifying innovation gaps, %	40–55	78–88	+33...35 p.p.
Accuracy of forecasting new directions, %	50–65	80–92	+25...30 p.p.
Decision-making time, days	20–30	3–7	4–6 times faster
Innovation strategy effectiveness index	0.45–0.55	0.70–0.85	+0.20...0.30

Source: author's own elaboration.

As the table shows, the NLP-AI model offers a considerable advantage over traditional analysis across all indicators. Monthly expert analysis time is reduced by 80–85 percent, while the innovation strategy effectiveness index increases by 0.20–0.30 points, strengthening the economic rationale for implementing the model.

DISCUSSION

The findings show that the efficiency of innovation activity management at textile industry enterprises is achieved through three interrelated directions: econometric assessment, improvement of the strategic management mechanism, and digital transformation. The strong influence of human capital indicators — particularly employees with specialized secondary education and those who have undergone qualification

training — confirms the need for enterprises to pay particular attention to workforce quality when improving production efficiency. This conclusion is consistent with the views of scholars such as J. Schumpeter, P. Drucker, and C. Freeman on the central role of human resources and knowledge in innovative development.

At the same time, the greater influence of technological innovation expenditures relative to R&D expenditures (0.73 versus 0.21) indicates that innovation activity at the enterprise is more practically and technologically oriented, while the integration of research findings into production remains insufficiently developed. From the perspective of M. Porter's theory of competitive advantage, this situation can be explained by the predominance of cost-reduction innovations over innovations aimed at product differentiation and new market segments, the latter being relatively less developed.

The proposed four-stage strategic management mechanism and the NLP-AI integration model complement existing research in two respects: first, they make it possible to organize innovation activity management within a unified system; second, by automating the analysis of patents and scientific literature, they increase the speed and accuracy of decision-making. At the same time, the effectiveness of the model depends on data quality, IT infrastructure, and the availability of qualified personnel; for small enterprises, initial investment costs and a shortage of qualified IT personnel remain the principal limiting factors.

A limitation of the study is that the econometric analysis was conducted using data from a single enterprise — "Parvoz Xumo Ravnaq Trans" LLC — which restricts the generalizability of the findings. Future research would benefit from extending the analysis to panel data covering several textile enterprises, as well as from evaluating the practical effectiveness of the NLP-AI model through long-term monitoring.

CONCLUSION

Based on the results of the study, the following conclusions were reached regarding the improvement of innovation activity management efficiency at textile industry enterprises:

- the number of production personnel, their qualification level, and expenditures on technological innovation and R&D have a statistically significant and positive effect on output volume;
- all identified elasticity coefficients are below one, indicating the need to improve the efficiency with

which the enterprise uses its existing resources;

- effective management of innovation activity requires a comprehensive strategic mechanism covering the stages of analysis, planning, implementation, and control;

- analyzing patents and scientific literature using NLP and artificial intelligence can reduce expert time by 80–85 percent while significantly improving the quality of innovation decisions.

In practical terms, it is recommended that enterprises improve their mechanisms for developing human capital, strengthen the system for integrating research findings into production, and implement a digital transformation roadmap in stages (ERP → IoT and data analytics → AI/ML integration). These measures will help bring innovation activity management at textile industry enterprises to a new, qualitatively higher level.

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