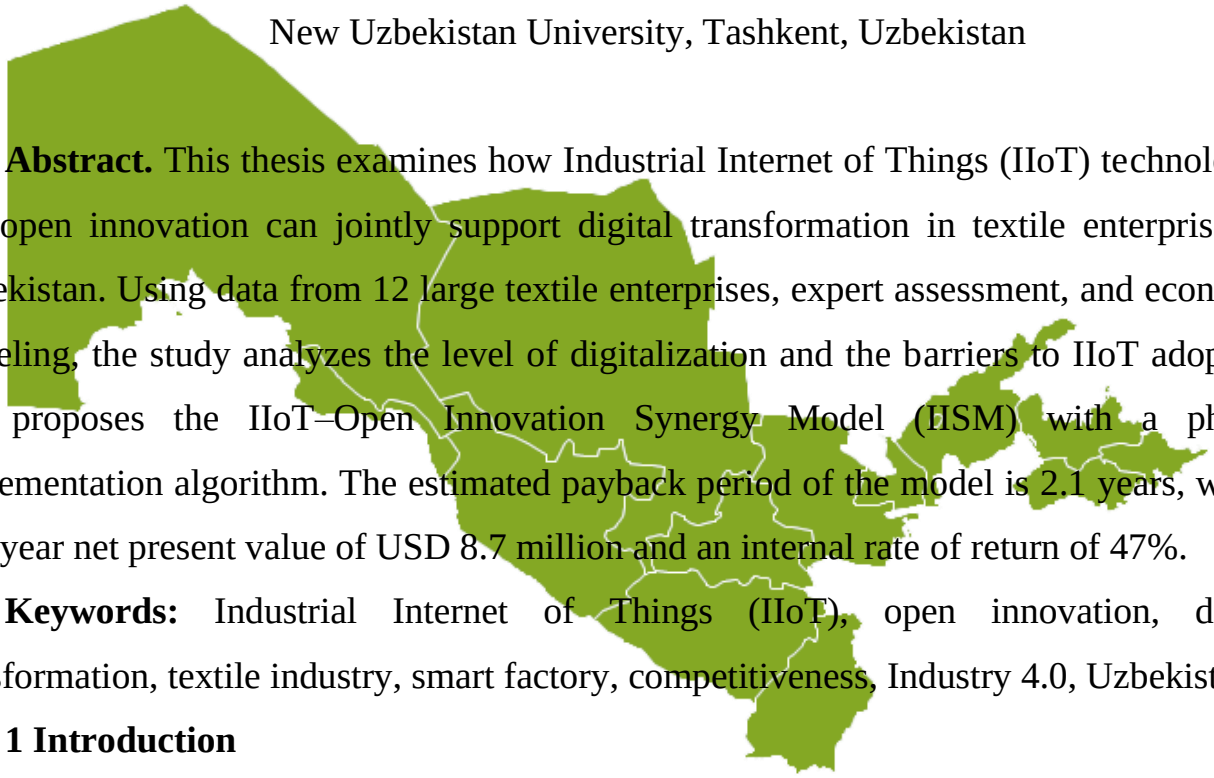
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A MODEL FOR MANAGING DIGITAL TRANSFORMATION IN TEXTILE ENTERPRISES THROUGH INDUSTRIAL IoT AND OPEN INNOVATION SYNERGY

Norova Dilnoza

New Uzbekistan University, Tashkent, Uzbekistan



Abstract. This thesis examines how Industrial Internet of Things (IIoT) technologies and open innovation can jointly support digital transformation in textile enterprises in Uzbekistan. Using data from 12 large textile enterprises, expert assessment, and economic modeling, the study analyzes the level of digitalization and the barriers to IIoT adoption, and proposes the IIoT–Open Innovation Synergy Model (IISM) with a phased implementation algorithm. The estimated payback period of the model is 2.1 years, with a five-year net present value of USD 8.7 million and an internal rate of return of 47%.

Keywords: Industrial Internet of Things (IIoT), open innovation, digital transformation, textile industry, smart factory, competitiveness, Industry 4.0, Uzbekistan.

1 Introduction

In the context of Industry 4.0, the textile industry faces growing global competition. Producers in Bangladesh, China, and India benefit from low labor costs, so textile enterprises in Uzbekistan can remain competitive only through technological innovation. According to McKinsey, enterprises that fully implement digital technologies reduce production costs by 15–25%, improve product quality by 20–35%, and shorten time to market by 30–40% [1]. The textile and apparel industry accounts for more than 60% of Uzbekistan’s exports and employs about 1.5 million people, which makes its digitalization a national priority reflected in the Digital Uzbekistan 2030 Strategy [2].

However, textile enterprises in Uzbekistan lack a scientifically grounded model for managing the combined implementation of IIoT technologies and open innovation. The aim

of this study is to develop such a model and to substantiate its economic effectiveness.

2 Literature review

The concept of Industry 4.0 originates in the German Industrie 4.0 initiative, which described the smart factory as a network of cyber-physical systems [3], and was later conceptualized by Lasi et al. as a shift towards decentralized, self-organizing production [4]. Vial [5] defined digital transformation as a process in which digital technologies trigger significant changes in an organization’s properties, requiring new value creation paths and the removal of organizational barriers. In the IIoT literature, Boyes et al. [6] distinguished IIoT from consumer IoT by its emphasis on reliability, safety, and integration with operational technology, while Sisinni et al. [7] highlighted requirements for real-time performance, interoperability, and cybersecurity. Porter and Heppelmann [8] showed that smart, connected products transform value chains and the basis of competition.

Open innovation, introduced by Chesbrough [9], assumes that firms use both internal and external ideas and paths to market. Laursen and Salter [10] found that the benefits of external search increase only up to a certain point, which indicates that openness must be managed deliberately. Frank et al. [11] showed that manufacturing firms adopt Industry 4.0 technologies in stages, and Bertola and Teunissen [12] demonstrated that in the fashion and textile sector digital technologies affect the entire value chain and require collaboration with external actors. Nevertheless, IIoT and open innovation are usually studied separately, and evidence from textile enterprises in Central Asian economies remains scarce. This study addresses this gap.

3 Research methodology

The study employed systems analysis, comparative analysis, expert assessment, interviews, statistical analysis, and economic modeling. Empirical data were collected from 12 large textile enterprises in Uzbekistan and supplemented with official statistics and industry reports [13, 14].

4 Results and discussion

The textile and apparel industry is one of Uzbekistan’s leading export sectors: in 2024, its exports reached USD 3.8 billion. Table 1 presents the key indicators of the sector.

Table 1. Key indicators of the textile industry in Uzbekistan, 2021–2024

Indicator	2021	2022	2023	2024
Exports (USD billion)	2.1	2.7	3.3	3.8
Number of enterprises	2,870	3,120	3,450	3,680
Employment (thousand people)	1,230	1,340	1,430	1,520
Digitalization level (%)	12%	18%	24%	31%
Enterprises using IIoT (%)	2%	5%	9%	14%

Although the level of digitalization increased from 12% in 2021 to 31% in 2024, it remains well below that of Germany (78%) and China (65%). The survey of 12 enterprises showed that the main barriers to IIoT adoption are high initial investment (67% of enterprises), a shortage of qualified IT personnel (58%), weak internet infrastructure (44%), and cybersecurity risks (39%).

Based on these findings, the IIoT–Open Innovation Synergy Model (IISM) was developed for textile enterprises. The model comprises four layers (Figure 1) and is based on the principles of modularity, openness, scalability, and security.

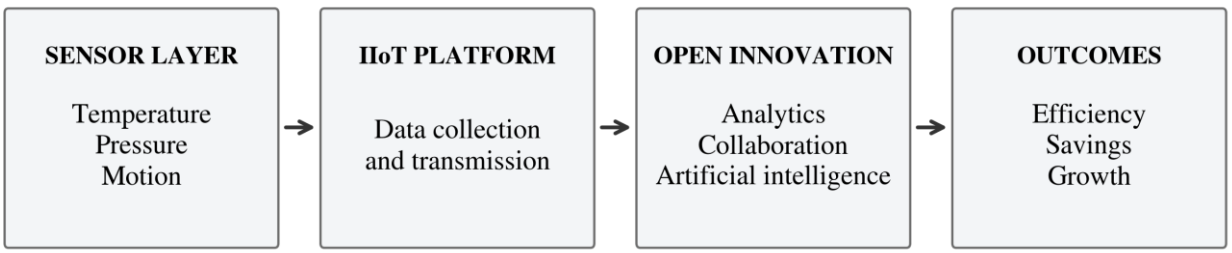


Figure 1. Architecture of the IIoT–Open Innovation Synergy Model (IISM).

The model is implemented in five phases: diagnostics (months 1–3), pilot implementation in one workshop together with local IT startups and universities (months 3–6), enterprise-wide scaling (months 6–18), development of an industry ecosystem (months 18–36), and industry leadership through standards, patents, and exports (from month 36).

The economic effectiveness of the model was calculated over five years for a medium-sized enterprise producing 10 tonnes of fabric per day. With an initial investment of USD 2.4 million and annual operating costs of USD 0.18 million, the model generates annual savings of USD 0.80 million from the first year and additional revenue of USD 1.40 million from the second year. The payback period is 2.1 years, compared with an industry average

of 3.4 years; the five-year NPV is USD 8.7 million at a 12% discount rate, and the IRR reaches 47%.

5 Conclusion

The study shows that the combined implementation of IIoT and open innovation can substantially accelerate the digital transformation of textile enterprises in Uzbekistan. The proposed IISM model and its five-phase implementation algorithm provide enterprises with a practical management tool, and the ROI analysis confirms its economic effectiveness.

Enterprises are recommended to begin with a digital maturity audit and a low-cost pilot project, such as energy monitoring or quality control, and to establish partnerships with local IT startups and universities. The government is recommended to introduce tax and import duty incentives for IIoT equipment, create an open innovation platform for the textile industry through public–private partnership, and include IIoT courses in vocational education programs.



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