DOI 10.15826/vestnik.2023.22.1.004 *Original Paper*

Assessment of Economic Efficiency, Effects and Risks of Digitalization Projects of Garment Industry in Russia

***Tatiana Yu. Kudryavtseva*[1], *Ksenia S. Kozhina*[1] ✉,**
***Gunnar K. Prause*[2], *Eunice O. Olaniyi*[3]**

[1] *Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia,*

[2] *Tallinn University of Technology, Wismar University, Tallinn, Estonia,*

[3] *University of Turku, Turku, Finland*

✉ *kozhina_ks@spbstu.ru*

Abstract. To increase production efficiency at industrial enterprises, various digital technologies have recently been used, which have various effects: reduction of time, money, material costs, reduction of the production cycle, productivity growth. This study aims to analyze and evaluate the efficiency of the digitalization of garment production, determine the effects and risks of a digitalization project. The digitalization project was carried out using the radio-frequency identification technology to monitor the sequential processes of garment making.This study tests a hypothesis that the use of digital technologies leads to a reduction in time losses and an increase in labor productivity. During the study, the time of the production process was measured. Further on, the possible reduction of time losses due to the introduction of digital technology under the conditions of existing production capacities is calculated. Time losses were used for additional production, which leads to a change in the company's cash flows. As a result, the performance indicators of the investment project were calculated, and its risks were assessed using sensitivity analysis.The theoretical significance is in determining the economic indicators that are affected by the introduction of digital technology in the garment industry. The introduction of the radio-frequency identification technology makes it possible to monitor the parameters of the production process, which helped to reduce time loss by 50%, decrease the labor intensity of the product and increase the productivity of the enterprise's personnel by 30%. The implementation of digitalization projects has risks for companies. To minimize possible risks that could arise, sustainable mitigating solutions were proffered.

Key words: garment industry; digital technologies; smart production; Industry 4.0; risk assessment; sustainable development; economic efficiency; investment impact analysis.

JEL L67

1. Introduction

Many manufacturing initiatives started all around the globe to make production smarter, achieve higher flexibility, speed up production cycles and increase sustainability. A promising approach seemed to be the fusion of the virtual and the real world, i. e. deriving a linkage between the internet and the manufacturing to facilitate dynamic production networks for flexible and open value chains of complex mass customization products in small series up to lot size one production [1]. One often referred approach represents the concept of the «Industry 4.0»

  ISSN 2712-7435

that targets energy and resource efficiency, increased productivity, shortening of innovation, and time-to-market cycles together with a horizontal and vertical integration through value networks and end-to-end digital integration of engineering across the entire value chain [2].

All realization concepts for smart production are based on digital technologies that include internet-based solutions to formulate new challenges on management techniques, business model innovation, and organizational development. In other words, they affect all spheres of human life [3]. Thus, digitalization as a prevalent phenomenon simplifies the work and the management of production as a whole – an individual process that improves the sustainability of the economic growth of industrial enterprises [4].

The spotlight of the current study targets the Russian textile industry; a sector plagued with technological lag linked to an underdeveloped digitalization level and sustainability concepts [5]. The industry tends to mass customize products, thus it is possible to produce a large number of variations of one product without accounting for the individual requirements of the customers [6]. As a result, the main factor of competition for the industry is the time of market launch comprising product development as well as time-to-market cycles, which in turn would depend on the level of digitalization of the production process [7].

To eliminate these negative consequences and increase the sustainability of the development of this industry, fundamental changes in the company's production processes are required as emphasized by [8]. The use of new digital technologies that involve a reduction in decision-making time and value chain i. e. a significant reduction in the time of implementation and realization of projects looks like a promising solution [4]. The smart production concepts such as the Industry 4.0 led to new supply chain paradigms based on intertwined manufacturing networks. It aims to change the roles of designers, manufacturers, and clients including supply chain actors, and further enables the identification and tracking of individual products during their entire life cycle making it possible for products to choose their way through a full value network [2].

Digitalization of the industry gives a number of positive effects, contributes to the creation of competitive advantages. Nevertheless, digitalization projects carry many potential risks that can have a negative impact on the activities of companies. These include operational risks, technology implementation risks, technical and informational risks. The human factor and technological limitations can negatively affect digital changes in the production process of companies. It is important to consider risks and minimize them.

So far, literature review [9; 10] revealed a research gap in the assessment of the economic impacts and risks of digitalization projects that influence output, worktime, daily production rate, and personnel productivity in the Russian textile industry based on the system dynamics method.

The purpose of the research is to analyze and evaluate the efficiency of the digitalization of garment production, determine the effects and risks of digitalization project.

The hypothesis of the study is the assumption that the use of digital technologies leads to a reduction in time losses and an increase in labor productivity.

The authors used empiric data of a digitalization project of a sewing company using the radio-frequency identification (RFID) technology to track textile production in real-time to enable the integration of digital technologies and lean manufacturing tools to reduce time loss

and, as a result, reduce labor costs, increase output and accelerate turnover.

For the economic efficiency of any production, right from production decision, execution, control, and distribution, every economic good must be optimally allocated and used, so that in the event of unforeseen interruption or deviation, the quality of products is not compromised [1, 3, 7]. The paper provides insight into how the deployment of integrated digital technologies like RFID can lead to increased efficiency of companies, and enhance sustainable industrial growth. The assessment model developed by this study is a real-time visual production tracking system that enables efficient production targeted toward today's extremely volatile production markets. The continual efficiency monitoring and assessment of the digitalized project will trigger timely and strategic managerial decisions to control unobtrusive production errors and eliminate hidden wastes.

The study fieldwork (the process of observation) to obtain information on financial and sustainable indicators commenced in January 2021 until June. The authors complemented the findings with expert interviews and validated the result with a case study.

The remaining part of the work is organized in the following manner. The next section is a review of various digital technology tools to improve productivity. This is followed by a detailed account of the methods used in section 3. Section 4 highlights the study results while the results' implications were disused in section 5. The authors concluded the study in the last section.

2. Literature Review

The industrial sector represents a key driver of research, productivity and job creation. Veugelers [11] explained that industrial processes are responsible for 80 % of the EU's private innovations and 75 % of its exports.Yet, statistical figures still reveal that the global share of European manufacturing value dropped from 36 % in 1991 to 25 % in 2012. This would explain why after years of long decline of manufacturing, the issue of re-industrialization experienced a renaissance on Western economic agenda.

With the new interest in the industrial sector, sustainable development issues also became a more popular research topic [12]. However, as with most countries and sectors, the sustainable development of the Russian garment industry can only be achieved if the problems highlighted earlier are eliminated with practicable and suitable solutions to production digitalization.

Fritzsche & Gölzer [13] shows the impact of the introduction of digital artificial intelligence in most industries, and came to the following conclusions: (1) Productivity will grow by 60–65 % in automotive, energy, transportation, and trade. The productivity of industrial enterprises on average will be able to grow by 40 %; (2) Operational efficiency will increase by 35 % in the pharmaceutical industry. Industry, trade, and energy sectors efficiency will increase by 15–20 %; (3) Best increase in the quality of work will occur in the automotive industry. The quality of pharmaceutical products will increase by 70 %; (4) Quality of industrial goods will increase by 30 %.

Other than this, many studies have also published different success stories of how digital technologies led to increased efficiency in various fields and sector and the development company. These results apply to industries in various countries, but the efficiency may differ due to the different levels of companies' readiness for digitalization and government support as now shown in the following.

Shan et al. [14] studied the use of industrial Internet as digital technology

in heavy industry by considering the case of *Sany* Heavy Industry, a Chinese multinational heavy equipment manufacturing company. The results show that *Sany* implemented a smarter production to improve the efficiency of the business processes, which led to an increase in productivity by 8%. Besides this, *Sany* was able to improve the timeliness of order fulfillment by 14%, reduce energy consumption per unit of production by 8%, reduce raw material reserves by 30% and achieve an improved quality of products up to 100%. The share of timely delivery itself was 95%.

Jones et al. [15] investigated the use of RFID technology in production with calibrated tools focusing on the efficiency of implementation. The research brought to light that this technology is able to reduce labor costs, audit costs, proper use of tools and measurement accuracy. A detailed financial analysis of the use of RFID technology further showed a reduction of labor costs up to 20% together with savings related to process optimization of about $60,000 while the net present value of the project was $4.5 million and the payback period ranging around 3 years. However, it is worth noting that this study did not take into account the maintenance of this technology.

Iluore et al. [16] studied the use of Real-Time Energy Management (RTEM) technology as digital technology to increase the efficiency of industrial equipment. This technology provides the exact location, status, condition, and maintenance history of an asset. From their research, Iluore et al. revealed that digitalization led to an increase of equipment usage by 30.8%. The research brought to light that this technology automates workflow, saves time, reduces potential errors, and improves coordination of work.

Barosz et al. [17] simulated production lines using human resources and robots and tested them at some factories in Poland. A detailed analysis of using robots in production showed an increase in productivity by 30% but additional increase in overall factory activity by 18% due to the exclusion of human factors such as fatigue, slow work, high error rate, and high labor cost. In this case, technical and organizational problems arose during the approbation from equipment failure, power supply disruption, and insufficient quality.

Fu M. et al. [18] studied the use of digital twins. This research showed that the digital twins achieved the following: time reduction for production planning and product launching; system technical support; enhanced integrated system for production control automation; improved production personnel management that allows remote team participation; and simplified operations execution.

Khan et al. [19] studied the Electronic Asset Development program. The research showed that this program led to increased efficiency of information transmission. The processing of using sensors installed on key elements of logistics schemes of oil refineries also improved. A detailed analysis of the use of industrial Internet by Khan et al. [19] showed an increase of industrial capacity by 20%, with further improved productivity corporation and optimization of production processes in the use of industrial Internet as a digital technology by United Engine Building Corporation.

Tsyokhla et al. [20] also investigated the use of the SharePoint Online (SPO) platform to build an engineering data management system. The result revealed that the SPO platform led to decreased work time spent on search and processing of technical information by 30%. The payback period of the digitalization project ranged around 3–4 years due to reduced design time, time of commissioning equipment into commercial operation, increased

volume of production, and sale of finished products.

Ilyina et al. [21] brought to light that the RFID-technology used by *Transneft* reduced equipment downtime, increased transparency and control of logistics processes, optimized warehouse operation, and transport, and improved labor productivity. A detailed financial analysis of the use of RFIDtechnology showed an annual saving due to the introduction of technology that was about 4.3 million rubles, and the payback ranged around 1 to 2 years.

Table 1 presents a compiled comparative analysis of the effects of the digitalization of industries enumerated above.

Table 1 presents cases of the introduction of digital technologies into production in various fields. RFID technology is actively used in textile industry at the moment. This technology allows you to read information at a distance without additional actions. RFID technology is used in textile industry at various stages: in production, in supply chains, in shops when selling.

Table 2 presents the results of research on using this technology in textile industry, as well as the effects that will be obtained after the technology introduction.

Table 2 shows the results of cases involving the RFID technology introduction in various areas of textile industry: in production, in the logistics system, shops. Based on the results of analyzing of cases on the RFID technology introduction during sales in the shop, stocks were reduced by 13%, the speed of reading tags from clothes was increased and time for picking clothes

Table 1. **Comparative analysis of the efficiency of digitalization of industries**

Author	Technology	Effects obtained in the author's study	Effects obtained as a result of digitalization
Shan S. [14]	Industrial Internet Technology	– productivity growth by 8%	– productivity growth by 30%
		– delivery time 95%	– timeliness of order execution 100%
Jones E.C. [15]	RFID	– reduction of labor costs by 20% – payback period of the project of 3 years	– reduction of labor costs by 30% – payback period of the project of 4 months
Iluore O.E., Mamudu Onose A., Emetere M. [16]	RTEM	– increase in equipment use by 30%	– productivity growth by 30%
Barosz P., Gołda G., Kampa A. [17]	Manual laborrobotization	– productivity growth by 30%	– productivity growth by 30%
Tsyokhla S. Yu., Simchenko N. A., Moiseenko V. A. [20]	Digital Platform	– worktime saving by 30%	– worktime saving by 25%
		– payback period of the project of 3-4 years	– payback period of the project of 4 months
Khan A. R. [19]	Industrial Internet of Things Technology	– 20% increase in equipment utilization	– productivity growth by 30%

Table 2. **Results of RFID technology introduction in textile industry**

Author and title of the work	Effects of the RFID technology introduction	Quantitative result
	Shops	
Denuwara, N., Maijala, J., Hakovirta, M. Sustainability benefits of RFID technology in the apparel industry [5]	– inventory management; – theft protection – checking of picking in shops	– reduction of stocks by 13 %; – availability of inventory in shops has increased to 90 %; – increase the speed of reading tags from clothes by 100 %; – saving time on picking clothes 87 %
	Supply chains	
Ali, A., Haseeb, M. Radio frequency identification (RFID) technology as a strategic tool towards higher performance of supply chain operations in textile and apparel industry of Malaysia [6]	– increased productivity due to faster transmission of information and reduced delivery time	
Chanchaichujit, J., Balasubramanian, S., Charmaine, N. S. M. A systematic literature review on the benefit-drivers of RFID implementation in supply chains and its impact on organizational competitive advantage [8]	– cost reduction; – improving the quality and safety of products; – reduction of equipment nonconformance; – improving the information exchange and integration in real time; – increasing the supply chain transparency; – operational collection of a large amount of data for analytics	
Denuwara, N., Maijala, J., Hakovirta, M. Sustainability benefits of RFID technology in the apparel industry [5]	– increasing the supply chain transparency; – asset tracking; – tracking of transport units; – increasing the loading accuracy in logistics	– increasing the inventory accuracy by 65–99 %; – reduction of errors in determining the location of goods by 90 %

End of table 2

Author and title of the work	Effects of the RFID technology introduction	Quantitative result
Production		
Choi, T. M., Yeung, W. K., Cheng, T. E., Yue, X. Optimal scheduling, coordination, and the value of RFID technology in garment manufacturing supply chains [7]	– profit growth due to shorter production time	– reduction of the production cycle by 16.7 %
Denuwara, N., Maijala, J., Hakovirta, M. Sustainability benefits of RFID technology in the apparel industry [5]	– improving the acceptance of materials; – tracking the material flow in the production process	– reducing the order planning time by 5–10 %; – reduction of errors in determining the location of materials by 50–80 %; – sales growth by 100 % due to the reduction of outstanding orders; – reduction of material processing time by 10–20 %
Wong, C., Guo, Z. X. (Eds.). Fashion supply chain management using radio frequency identification (RFID) technologies [10]	– increase in production efficiency by 50 %	– reduction of downtime by 30 %; – reduction of time losses during production by 50 %; – reduction of defects by 30 %

was saved by 90 %. Thus, in shops, theft protection and inventory management in warehouses in shops have been improved.

RFID technology is most often used in the supply chain, that is, when regulating supplies. With the help of this technology, the inventory accuracy increases by 80 %, and errors in determining the location of goods will be reduced by 90 %. Thus, the supply chain transparency will increase, the product delivery safety will increase, and the integration of real-time information on the location of goods will improve.

RFID technology is also used in the production process, which allows to reduce the time in the production of goods. Temporary losses in production are reduced, as well as equipment downtime. In addition, with the help of this technology, it is possible to track problems in the production process in real time. Thus, RFID technology in the production process makes it possible to reduce time losses both by reducing the production cycle and by operational management when tracking bottlenecks in real time, which will subsequently increase production capacity.

The implementation of digital technologies brings many positive effects at different stages for the company, but also carries a number of risks that need to be analyzed and minimized. There are two groups of risks that a company may have from the implementation of digital technologies:

1) Risks of the "knowledge economy" (knowledge), which include talent management (creation, attraction, and

development), personnel training (training and education), and development of science (scientific concentration);

2) Infrastructural risks (technology), which include institutional infrastructure (regulatory framework), financial infrastructure (capital), and ICT infrastructure (technological framework), slow changeover of business processes [23; 24].

One of the risks associated with the implementation of RFID technology is the risk of information security. Competitor potentially could gain unauthorized access to RFID-generated information and use it to harm the interests of the organization implementing the RFID system [25]. They also highlight the risk of the company's business processes. Already established business processes may be disrupted by the introduction of RFID technology [34]. There are also external risks. RFID technology potentially could represent a threat to non-RFID networked or collocated systems, assets and people [25].

Denuwara et al. [5] identified two types of risks: (1) environmental risks where natural resources get depleted due to material production and the air and water gets polluted from the harvesting and manufacturing processes of the material; (2) social risks related to inhumane working conditions where production is outsourced to lower labor cost countries in order for organizations to remain competitive.

Also, the implementation of digital technologies to improve the efficiency of the company in textile industry is challenging due to financial pressure on management to reduce costs and reduce lead times [5].

The highlighted cases presented the significant economic and production efficiency improvements from the implementation of digitalization. Still, the review exposed the absence of a holistic and coherent methodology or taxonomy to assess the economic impacts of digitalization in manufacturing. The referred case studies also brought to light that depending on the business sector or the chosen technology, different types of efficiency parameters dominate the results but these parameters are dynamically linked. This dynamic interdependency of parameters noticed in digitalization projects led to the current study approach and inspired the need to develop an appropriate system dynamic model for economic efficiency assessment that can be empirically validated according to Sterman [22], whereby in this case, the authors used a garment industry in Russia.

3. Materials and Methods

3.1. Object of study

LLC *Sportego* is a St. Petersburg sewing company engaged in the production of sportswear. The company implements lean manufacturing and follows the value principle as an integral part of the concept of lean manufacturing. Value is a set of qualitative and quantitative properties of a product or service that allows meeting the needs of the consumers [22]. The production activities of the company for each operation are divided into three categories: actions that add value, forced work, and time loss [26].

The company plans to implement a digitalization investment project for technological process of the production of sublimation molds. The project involves the introduction of RFID technology to improve the efficiency of the implementation of the principle of lean manufacturing values. This technology automatically measures each operation using the three classifications and based on the data obtained, the company's managers will be able to reduce production loss through the introduction of lean manufacturing tools [27].

The authors divided the digitalization project implementation into three stages:

Stage one: The digitalization project process

Stage two: Economic parameters analysis

Stage three: Project economic efficiency measurement

3.2. The digitalization project process

The purpose of the investment project for digitalization by Sportego is to introduce technology for tracking the production of sublimation molds in real time. According to Baptista et al [28], to achieve successful digitalization of the workflow for the production of sublimation molds, the digitalization project must be implemented for all production.

Thus, this technology will:

1) Monitor each unit of production at a specific stage of production [29];

2) Monitor bottleneck in production, globally (optimization of the entire production process) and locally (determination of the place where the production process is inhibited) [30];

3) Monitor the production process of each order on the company's website, enabling each client to track what stage the order is as well as stage of readiness [30; 31];

4) Develop a key performance indicator system (KPI) to control defects and increase employee motivation to increase productivity [32].

3.3. Economic parameters analysis

The introduction of RFID technology affects the productivity of the company, which is determined by two indicators: the labor intensity of manufacturing for a set of products and the output of the production per each personnel. Labor intensity is directly related to output, worktime, daily production rate, and personnel number.

It is expected that the digitalization project will lead to a reduction in labor intensity of manufacturing (by reducing time loss with the help of lean manufacturing tools), and with constant work time and the number of employees, increase the daily production rate.

The growing output, in turn, will entail both an increase of revenue as well as an increase in variable costs, which include material costs that encompass the cost of RFID tags for each unit of product, plus the labor costs of commercial personnel (since the salary of commercial personnel in *Sportego* depends on the company's revenue).

The investment project generates investment costs, which represent the cash flow from investment activities. Furthermore, the investment requires a source of financing, which will be reflected as cash flow from financing activities. The project is linked to the introduction of new equipment, for which depreciation will be calculated, directly affecting profits and tax payments.

3.4. Project economic efficiency measurement

To calculate the economic efficiency, it is necessary to calculate the cash flow of the investment project for the introduction of RFID technology for three types of activities:

- Operating activities (includes an increase in output and operating costs);
- Investment activities (includes investment costs);
- Financial activities (includes the cost of financing source).

Other relationships between the project indicators taken into account in the cash flow when calculating the efficiency of the project are further described in section 4. However, to calculate cash flow, it is necessary to conform to the following algorithm:

Calculate cash flow from operating activities such as:

1) The additional revenue of the company due to additional output. Determine the percentage of reduction in time loss, which will reduce the labor intensity of the unit production;

2) The increase in material costs due to the introduction of RFID tags. Calculate the increase in defects;

3) The increase in the wage fund of commercial personnel;

4) The additional tax on profits from the project;

5) Calculate the cash flow from investment activities, which includes investment costs for the purchase of equipment and software;

6) Calculate the cash flow from financial activities, which includes the source of finance of the investment project;

7) Calculate the performance indicators of the investment project and evaluate the sensitivity of all project indicators. While doing this, the authors considered the reduction of time loss and demand for products.

4. Results

The RFID technology allows monitoring the production process to enable making strategic and managerial decisions from the visualization of real-life information obtained in tabular and graphical forms [33–35].

To implement the technology for tracking production in real-time, the market for these technologies was analyzed. In Russia, this technology is not in use especially in the production process at the garment enterprises. The analysis of the foreign technology market reveals the problem of restrictions on the import of these technologies to Russia in the context of sanctions.However an analog of the European and Asian technologies was found in the Russian market at *First Bit*, a global IT-company.

Thus, the technology chosen for the project operates on the following principles: an RFID reader attached to each workplace. All readers in the flow network and connect to a single computer to gather data. The RFID tag is programmed for each unit of production. These labels are attached to the fabric piece through the production flow. The data acquisition computer receives data

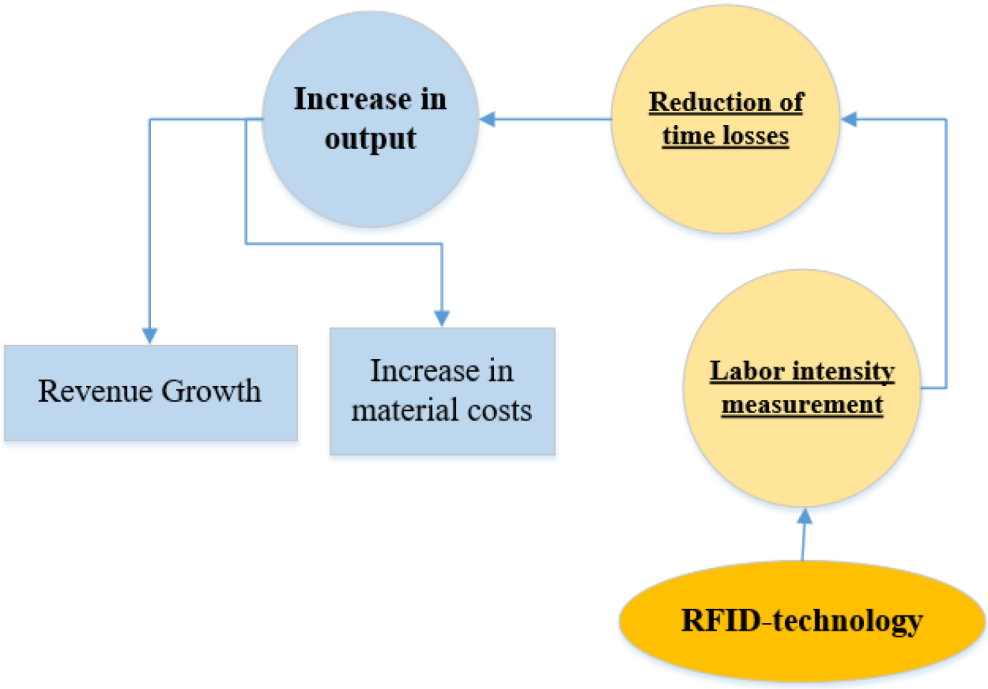

Figure 1. Diagram of the impact of RFID technology (the authors)

from all label readers through all stages of the process and updates production information in real-time [36]. The obtained data is analyzed and displayed in report form and graphs that represent a corresponding system dynamics model.

The RFID technology introduction will result in changing cash flows: operational, investment and financial ones, which are discussed in more detail in paragraphs 4.1–4.3. Figure 1 shows the scheme of RFID technology operation at the enterprise.

With the help of RFID technology, the Sportego company will measure the labor intensity of each operation: the time of adding value and time losses. Based on the data obtained, decisions will be made to reduce time losses, due to which output will increase. This will lead to an increase in the company's revenue and an increase in material costs.

4.1. Economic parameters analysis and efficiency measurement

The cash flow from operating activities consists of revenues in the form of revenue from additional output and payments because of an increase in operating costs. The following evaluation result was obtained.

Additional revenue. With the help of RFIDtechnology, the authors carried out an analysis of reduction in labor intensity of manufacturing products and increase in output by reducing the time loss presented in Table 3.

Time loss was identified from continuous observation and measurement of the duration of each sublimation operation from each production process, the results of which are presented in Figure 2, which shows that the time loss account for 46% of the labor intensity of the product.

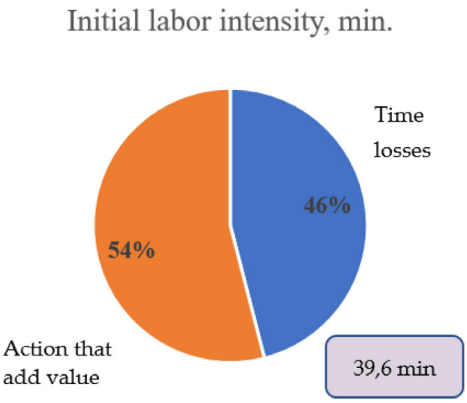

Figure 2. The initial labor intensity of manufacturing sublimation molds (the authors)

Table 3. **Changes in labor intensity of operations due to changes in time loss**

Loss reduction, %	Labor intensity of the operation, min.	Additional output, sets	Daily rate of production, sets
90	23.2	178	428
80	25.1	146	396
70	26.9	119	369
60	28.8	95	345
50	30.6	75	325
40	32.4	56	306
30	34.3	40	290
20	36.1	25	275
10	38.0	12	262
0	39.8	0	250

The hot press (sublimation equipment) limits the production capacity of the enterprise because it produces no more than 325 sets of products per day; in this regard, the maximum possible reduction in time loss is 50%. Based on the results obtained, Table 4 provides information on the monthly volume of production while reducing time loss by 50%.

With a 50% reduction in time loss, the daily production volume of the sublimation mold flow was 325 sets. Based on this, the total monthly production volume became 9 750 sets. *Sportego's* productivity increased by 30%. The average price of a T-shirt is 850 rubles; the price of shorts is 700 rubles. In total, the cost per set is 1 550 rubles. Monthly revenue for the production of 9 750 sets amounted to 15 112 500 rubles. The total increase was 3 487 500 rubles.

Increase in material costs. The initial material costs of the product set were determined, which amounted to 393 rubles. After the introduction of RFID technology, material costs amounted to 544 rubles due to the introduction of RFID tags for each unit of the product (Table 5). As a result, material costs increased by 38%.

To calculate the growth of defects, the rate of permissible defects was determined, which amounted to 2% of the total production. The main volume of production amounted to 7 500 sets per month, additional was 2 250 sets. Based on this, the total monthly production volume was 9 750 sets and 9 540 sets excluding those with defects. Consequently, the

Table 4. **Production Output Volume**

	Main production volume	Additional production volume
Models of clothes for calculation	Soccer uniform (T-shirt + shorts)	
Daily production, sets	250	75
Permissible rate of defects,%	2	2
Monthly production volume, sets	7 500	2 250
Monthly total production volume, taking into account defects, sets	9 750	
Monthly total production excluding defects/sets	9 540	
Price per unit, rub.	1 550	
Monthly sales revenue, rub	14 787 000	

Table 5. **Impact of the investment project on the company's performance**

Indicators	Change in indicators, %
Revenue growth	30
Increase in material costs	30
Growth in defects	30
Increase in the wage fund of commercial personnel	18
Increase in tax on profits	11

increase in the number of defects amounted to 45 sets (Table 5). Revenue growth, taking into account defective products, amounted to 3 417 750 rubles.

Increase in the wage fund of commercial personnel. Payroll calculation was determined as 3 % of the company's revenue. The payroll of other employees remained unchanged since the organization has a time-based salary for production personnel. Table 4 also shows the increase in the wage fund of commercial personnel during the implementation of the investment project.

Additional tax on profits from the project. The company's revenue, current costs, fixed production costs, depreciation of new equipment, interest payable on the loan were taken into account. Revenue from the sale of an additional 75 units amounted to approximately 3.4 million rubles. The increase in monthly tax on profits was about 50 000 rubles or 11 % (Table 5).

4.2. Cash flow from investment activities

The proposals of First Bit were studied, which represent the investment costs for the purchase of equipment and software are presented as investment costs in Table 6.

The resulting investment costs are calculated based on the area of the facility in which the production is located and the number of production lines (1 sublimation mold production flow). In total, the investment costs amounted to 2.7 million rubles. In addition, the installation of the software resulted in monthly maintenance costs of 100 000 rubles per month. All of these were taken into account in the current costs.

4.3. Cash flow from financial activities

The authors analyzed the financing sources for the project and considered the state support, measures own funds, and a bank loan. The state financial support measures included Industrial Development Fund programs and subsidies. The minimum loan specified in the terms of the Fundamental Research Program (FRP) programs amounted to 5 million rubles, which is almost 2 times higher than the investments needed for the project, as a result, the company could not receive state support.

Since the company did not have the funds to support the project, a 2.7 million rubles loan with a rate of 11.5 % was taken. The form of payment was a differentiated payment of 20 months.

4.4. Performance indicators of the project

Table 7 shows the calculation of the project income and its payback.

Information on the company's net profit was aggregated, which amounted to 827 300 rubles, for a 20 monthly installment

Table 6. **Investment costs**

Object of expenditure	Price, thousand rubles	Quantity	Cost, thousand rubles
Printer	500	1	500
RFID readers	150	10	1 500
Installation of equipment	100	1	100
Software development	500	1	500
Personnel training	100	1	100
Total			2 700

Table 7. **The project income and payback**

Month	Cash flow, rub.	Cumulative cash flow, rub.	Net cash flow, rub.	Payback (yes/no)
1	679 206	679 206	-2 020 794	No
2	681 006	1 360 213	-1 339 788	No
3	533 653	1 893 866	-806 135	No
4	684 607	2 578 474	-121 528	No
5	686 407	3 264 881	564 879	Yes
6	538 355	3 803 237	1 103 234	Yes
7	690 008	4 493,245	1 793 242	Yes
8	691 808	5 185,053	2 485 050	Yes
9	543 057	5 728 111	3 028 107	Yes
10	695 408	6 423 520	3 723 515	Yes
11	697 209	7 120 729	4 420 724	Yes
12	547 760	7 668 489	4 968 484	Yes
13	703 125	8 371 614	5 671 609	Yes
14	704 715	9 076 329	6 376 324	Yes
15	554 358	9 630 688	6 930 682	Yes
16	707 897	10 338 580	7 638 579	Yes
17	709 487	11 048 070	8 348 066	Yes
18	558 431	11 606 500	8 906 497	Yes
19	712 669	12 319 170	9 619 166	Yes
20	714 259	13 033 430	10 333 425	Yes

plan of 851 900 rubles. In total, the net cash flow in the first period amounted to 679 200 rubles, and an increment later in each period, and by the 20th period amounted to 714 300 rubles. Next, the authors calculated the net present value of the project and the payback period of the project. The discount rate was made by the owners of the company to be 15% annually valued at 11 456 000 rubles, making the project attractive for investment. Thus, for a project that cost 2 700 000 rubles, the payback period was 4 months.

4.5. Risks of RFID technology

The implementation of RFID technology is effective for companies in the textile industry. But the introduction of digital technology leads to risks. The risk can be attached to internal and external ones.

Table 8 presents the internal risks that will exist when implementing RFID technology. The table presents three types of risks of the project, which were studied earlier in the reseaches [5; 34; 35].

With the reduction of losses in the labor intensity of operations, the productivity of

Table 8. **Internal risks of the company in the implementation of RFID-technology**

Type of risk	Risks	Consequences
Social risks	Risk of failure to achieve labor productivity target	– no increase in additional output by reducing the loss of working time fund; – increase direct labor costs
Risks of the «knowledge economy»	Risk of growth of defective production as a result of an increase in the rate of production and low personnel qualification	increase in material costs;reduce in the production of production personnel
Infrastructural risks	Risk of growth in equipment utilization	increase in deterioration of equipment;increase in the use of electricity
	Risk disconnected business processes	increase the time spent on transferring information between business processes;increase in the cost of production

production will increase, respectively, the output per employee will increase. But not every employee will be ready to produce more products at the same wage. In this regard, the maximum efficiency from the introduction of technology will not be achieved. So company has risk of of failure to achieve labor productivity targe.

With the increase in output, workers will increase labor productivity, and defective production may increase, due to the fact that they increase the speed of production and wokers have low qualification.

With the growth of production volume, the equipment utilization will increase. Accordingly, the deterioration of equipment will increase. In addition, electricity costs will increase.

One of the risks is the disconnected business processes in company: data received from sales managers is not automatically transferred to the production department. These actions require additional time to complete the order. To reduce the lead time and make it easier to analyze data from each business process, it is necessary to digitize all processes in the company.

There is also an external risk that the company cannot independently influence. It is risk of low demand for additional output of goods. If the company produces more products, the demand for products may change or remain at the same level.

4.6 Sensitivity Analysis

As part of the research, we assessed one internal risk (Risk of failure to achieve labor productivity target) and one external risk (risk of low demand for additional output of goods), which any project of digitalization can have.

An analysis of the sensitivity of the investment project was carried out according to two parameters: a) the share of reducing time loss in the total labor intensity of products and b) the demand for products. Analysis of the sensitivity of the project to the reduction in time loss was carried out according to the possible proportion of reduction from 1 to 50%.

Figure 3 shows the results of NPV and payback period while reducing time loss from 1 to 50 %.

The authors determined the most effective reduction in time loss by two criteria. First, when the NPV is greater than zero (NPV > 0) and based on the results in Figure 3, the NPV > 0 would be at least 36 % less time loss. Second, when the payback period is up to 12 months (i. e. the term of use for the RFID-readers is 12 months). The result shows that the payback period of the project will be 12 months with a minimum time loss of 42 %. The project will be effective while reducing time loss from 42 % to 50 %.

An analog analysis of the sensitivity of the project on the demand for products was carried. This is the analysis of the project efficiency in terms of the demand for additional production where the minimum number of sales of products was determined when NPV > 0. The result shows that the implementation of the project will be profitable with a demand for the additional output being at least 60 %.

Accordingly, the investment project will be cost-effective under the following conditions: (a) reduction of time loss in the labor intensity of operations should be at least 42 %; (b) sale of additional output should be at least 60 % of the maximum possible value. The implementation of the project is effective for garment companies.

5. Discussion

According to the analysis results, the project to introduce RFID technology into the production process at a garment factory will lead to a number of effects, which are presented in Table 9.

The project to introduce RFID technology into the production process of Sportego LLC will lead to production volume increase, and subsequently to revenue growth by reducing time losses by up to 50 % and an increase in production volume by 30 %. The project in question had a manufacturing capacity constraint that prevented any further reduction in downtime.

Similar results were obtained in a study by Wong & Guo [10], which also analyzed a 50 % reduction in time losses due to the introduction of such technology, resulting in a 50 % increase in production efficiency.

Analysis of the results of other research projects on the introduction of RFID technology in the production process of garment companies showed a 30 % reduction in defects, a 20 % reduction in material processing time. These indicators were not

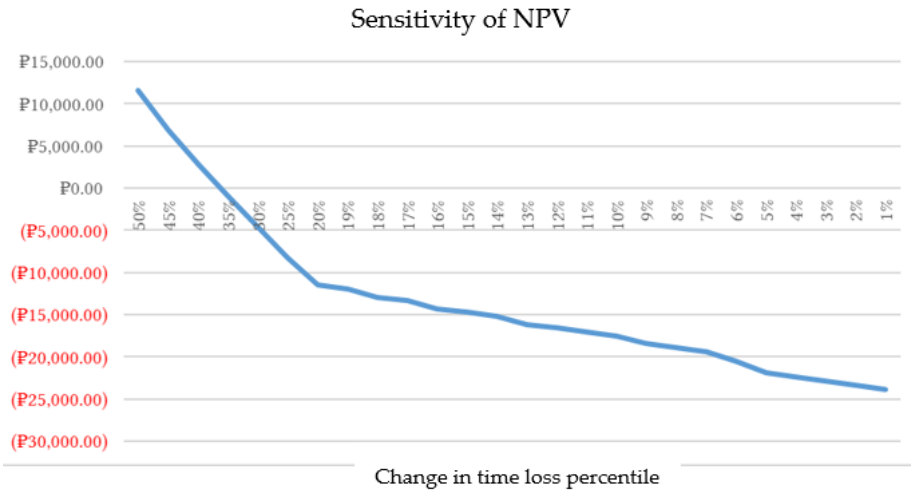

Figure 3. Sensitivity analysis of project to reduction in time loss operation (the authors)

Table 9. **Effects and quantitative results of the introduction of RFID technology into the production process for various stakeholders**

Category	Effects	Quantitative results
Buyer	Possibility of tracking the order readiness and at what stage of production it is now	
Owners	Increase the company efficiency	Revenue growth by 30% due to the reduction of time losses by 50%
Sales department manager	Possibility of advising the client about the order readiness	
Shop managers	Possibility of tracking bottlenecks in the production process by tracking production in real time	
Foreman	Possibility of redistribution of labor force between streams	
Production personnel	Labor remuneration growth	Wage growth due to productivity growth by 30%
Quality inspector	Possibility of tracking rejects	
HR Manager	Possibility of tracking the output of each employee for the wage calculation	

analyzed in the study on Sportego LLC and may be considered in future studies.

Also, the introduction of RFID technology in other areas of the garment industry will show other effects associated with increasing the inventory efficiency, optimizing inventory, which is applicable in shops or logistics.

Unlike all the analyzed projects on the introduction of RFID technology into the garment industry, the effects in which the company owners are interested were identified, in our work, the effects for various stakeholders were highlighted: owners, buyers, sales managers, production personnel, etc.

The implementation of the investment project for digitalization of a technological process for a garment enterprise with the help of RFID technology and lean manufacturing tools led to an increase in productivity by 30% due to an increase in the output of production personnel, reducing time loss in the production process by up to 50%. As earlier reported, the introduction of RFID technology in the production of calibrated tools led to a reduction in labor costs by 20% with a 3 years payback period [15], however from the current garment enterprise study, the reduction in labor costs was 30%, and the payback period was 4 months. This difference may be due to the specifics of industries, for instance, the garment industry is characterized by high turnover. In addition, the study did not take into account the current costs for the implementation of the technology, which may also bear a significant influence on the efficiency of its implementation

When *Sany* introduced industrial Internet technology, they were able to increase productivity by 8%, and achieve 95% timeliness delivery [8; 14]. This technology can be more effective if used in conjunction with lean manufacturing tools as successfully implemented by *Sportego*. Still, the technology (industrial internet technology) will increase energy consumption. RTEM technology is similar

to RFID technology, although it only monitors and focuses on the condition of the equipment. This technology can improve the use of equipment productivity by 30 % [16] but does not take into account personnel productivity, which may disrupt machine workflow. If mistakes are not caught early, total productivity will automatically reduce. The RTEM unlike the RFID seems to be suitable for enterprises with few working personnel and maximum automation of all production processes.

Even in the situation where robots were used to replace manual work to boost productivity by 30 % as studied by Barosz et al. [17], disruption of power supply and equipment failure led to a drop in the quality of manufactured products. The same with the use of the SPO digital platform that has helped the oil and gas industry to save working time by 30 %. However, the payback of such a project was between 3–4 years [20] which is a long time compared to the current study case that allowed the garment factory to save the working time of production personnel by 25 % with a payback period of 4 months. Furthermore, while the technology of the Industrial Internet of Things allowed increasing the capacity utilization by 20 % in the engine manufacturing industry with an increase in productivity [19], the current project, productivity growth improved by 30 % when used together with lean manufacturing tools.

The introduction of any digital technology will lead to the emergence of additional risks, primarily associated with the production process. The human factor can be a major operational risk factor. In addition, existing technological capacity may pose a risk of limiting the activity of new technologies.

Other researchers have most frequently identified the security risks associated with information obtained through RFID technology. Few studies have explored the inherent risks of garment companies in implementing RFID technology related to the manufacturing process. Nevertheless, the social risk associated with failure to achieve labor productivity target was highlighted both in the case presented in the study and in research of Denuwara [5] and Prasad [35]. Risk of failure to achieve labor productivity target of the workforce may lead to not achieving a reduction in time losses.

In research of Chen [36], external risks were noted, which are also highlighted in our work, associated with insufficient demand for an additional increase in production.

Summing up, agreed, the introduction of digital technologies can lead to increased efficiency of companies, and consequently, better enhance sustainable industrial growth; however, the choice of digitalization technology must be adjusted based on the specifics of the industry and the technological process.

In general, to increase the production efficiency in the garment industry, it is most effective to use RFID technology, which will help reduce time losses. Due to the released time, it is possible to increase output. This conclusion was confirmed by calculations in this paper and in the study of Wong & Guo [10].

The results of the study coincided with the results of studies by other authors, in particular with the results obtained in China, which confirms the hypothesis of reducing time losses and increasing labor productivity through the introduction of digital technology.

This work is limited by some elements that were not taken into account when calculating cash flow like the investments in current assets of the company and the product demand seasonality. These limitations may probably affect the performance of the company and are being considered in further studies.

Work has some limitations. But the authors, however, proffered applicable solutions to each challenge. The main advantage of the implementation of this system is the ability to track production in real time. This technology will allow identify problems in the production process, which will allow to quickly making necessary management decisions. Although, with the reduction in time loss, the labor intensity of operations will decrease and productivity will increase but a major limiting factor of productivity growth and loss reduction may demotivate employees to increase product defects due to the acceleration of production processes.

To solve this problem, it is necessary to introduce a KPI system with the key indicators predetermined and agreed upon by each category of employees taking into account the volume of production and the rate of defective products that affect the level of wages.

6. Conclusions

The study carried out an investment evaluation project for the digitalization of a technological process at a garment enterprise. The objective was to reduce time loss, which would reduce the labor intensity of the production of a set and free up the working time of employees, thereby creating extra time that can be channeled into the production of additional products.

The result shows that the investment project led to an increased output due to improved productivity by 30%, which was due to a reduction in the labor intensity of the product and an increase in the output of production personnel. In addition, because RFID tags will be required for each unit of the product, material cost increased by 38%. Taking into account the loan taken for the investment project (2.7 million rubles), the cost of the project with a reduction in time loss by 50% ended up amounting to 34 318 400 rubles.

The obtained results confirm the hypothesis that the use of digital technologies leads to a reduction in time losses and an increase in labor productivity. Net present value amounted to 30 186 65 rubles with a discount rate of 15% annually and a payback period of 4 months.

The result of risk analyzes (project sensitivity test) reveals that a reduction in time loss from 15 to 50% and an additional output of at least 42% will be cost-effective.

The implementation of the investment project led to a change in two types of direct costs: labor and material. Material costs went up but labor resource savings came from the labor intensity of the production of set products consisting of three-time respites: the time of adding value, the time for forced work, and time loss.

Another problem that may arise is the inconsistency of the production process with other business processes. For example, the data received from sales managers are not automatically transferred to the planning department for the preparation of materials for sewing products or to the production department. What happens is that whenever this information is manually collated, the production personnel and specialists would only receive orders on paper (order passport), which is passed to the Kanban boards at each stage of production. This further requires additional time. To reduce the time of order fulfillment and the convenience of analyzing data from each business process, it is necessary to digitalize all processes in the company.

This research is critical for the implementation of smart production concepts needed for the industrial revolution agenda that thrives towards digitalization and network manufacturing as sources of economic efficiency, high production flexibility, and sustainability.

The study is theoretically significant, it identifies economic indicators that are

affected by the introduction of digital technologies in the garment industry. These include time losses, material costs, labor productivity.

The results of the study can be used by other clothing companies to evaluate the effectiveness of the implementation of digital technologies.

References

1. Kagermann, H., Helbig, J., Hellinger, A., Wahlster, W. (2013) *Securing the future of German manufacturing industry*. Recommendations for implementing the strategic initiative INDUSTRIE4.0. Final Report of the INDUSTRIE4.0: Working Group. Berlin, Frankfurt.

2. Prause, G. (2015) Sustainable business models and structures for industry 4.0. *Journal of Security and Sustainability Issues*, Vol. 5, Issue 2, 159–169. DOI: https://doi.org/10.9770/jssi.2015.5.2(3).

3. Tjahjono, B., Esplugues, C., Ares, E., Pelaez, G. (2017) What does industry 4.0 mean to supply chain? *Procedia manufacturing*, Vol. 13, 1175–1182. DOI: https://doi.org/10.1016/j.promfg.2017.09.191.

4. Vrana J., Singh R. (2021) Digitization, digitalization, and digital transformation. *In: Handbook of Nondestructive Evaluation 4.0*. Pp. 1–17. Springer, Cham. DOI: https://doi.org/10.1007/978-3-030-48200-8_39–1.

5. Denuwara, N., Maijala, J., Hakovirta, M. (2019) Sustainability benefits of RFID technology in the apparel industry. *Sustainability*, Vol. 11, Issue 22, 6477. DOI: https://doi.org/10.3390/su11226477.

6. Ali, A., Haseeb, M. (2019) Radio frequency identification (RFID) technology as a strategic tool towards higher performance of supply chain operations in textile and apparel industry of Malaysia. *Uncertain Supply Chain Management*, Vol. 7, Issue2, 215–226. DOI: https://doi.org/10.5267/j.uscm.2018.10.004.

7. Choi, T.M., Yeung, W., Cheng, T.C., Yue, X. (2017) Optimal scheduling, coordination, and the value of RFID technology in garment manufacturing supply chains. *IEEE Transactions on Engineering Management*, Vol. 65, Issue 1. Pp. 72–84. DOI: https://doi.org/10.1109/TEM.2017.2739799.

8. Chanchaichujit, J., Balasubramanian, S., Charmaine, N.S.M. (2020) A systematic literature review on the benefit-drivers of RFID implementation in supply chains and its impact on organizational competitive advantage. *Cogent Business & Management*, Vol. 7, Issue 1, 1818408. DOI: https://doi.org/10.1080/23311975.2020.1818408.

9. Stepanova, D.I. (2018) Digital technologies of business management in the garment and textile industry of Russia [Cifrovye tekhnologii upravleniya biznesom v proizvodstve i tekstil-noi promyshlennosti Rossii]. *Design, technologies and innovations in textile and garment industry (Innovations-2018) [Dizain, tekhnologii i innovacii v tekstilnoi i massovoj promyshlennosti (Innovacii-2018)]*, Part 3. Moscow, 263–266. Available at: https://elibrary.ru/item.asp?edn=ywsgzf&ysclid=le28kpdp9a115774001. (In Russ.).

10. Wong, W.K., Guo, Z.X. (2014) *Fashion Supply Chain Management Using Radio Frequency Identification (RFID) Technologies*. Woodhead Publishing. DOI: https://doi.org/10.1016/B978-0-85709-805-4.50012–2.

11. Veugelers, R. (Eds) (2013) Manufacturing Europe's Future. *Bruegel Blueprint Series*, Vol. XXI. Brussels. Available at: https://www.bruegel.org/sites/default/files/wp-content/uploads/imported/publications/Blueprint_XXI_web_181113a.pdf

12. Prause, G., Atari, S. (2017) On sustainable production networks for Industry 4.0. *Journal of Entrepreneurship and Sustaibility Issues*, Vol. 4, Issue 4, 421–431. DOI: https://doi.org/10.9770/jesi.2017.4.4(2).

13. Fritzsche, A., Gölzer, P. (2021) Indutrial Applications of Artificial Intelligence: From Grand Stories of Digital Disruption to Actual Progress. *Procedia CIRP*, Vol. 104, 683–688. DOI: https://doi.org/10.1016/j.procir.2021.11.115.

14. Shan, S., Wen, X., Wei, Y., Wang, Z., Chen, Y. (2020) Intelligent manufacturing in industry 4.0: A case study of Sany heavy industry. *Systems Research and Behavioral Science*, Vol. 37, Issue 4, 679–690. DOI: https://doi.org/10.1002/sres.2709.

15. Jones, E.C., Riley, M.W., Franca, R., Reigle, S. (2007) Case study: the engineering economics of RFID in specialized manufacturing. *The Engineering Economist*, Vol. 52, Issue 3, 285–303. DOI: https://doi.org/10.1080/00137910701503951.

16. Iluore, O.E., Mamudu Onose, A., Emetere, M. (2020) Development of asset management model using real-time equipment monitoring (RTEM): case study of an industrial company. *Cogent Business & Management*, Vol. 7, Issue 1? 1763649. DOI: https://doi.org/10.1080/23311975.2020.1763649.

17. Barosz, P., Gołda, G., Kampa, A. (2020) Efficiency analysis of manufacturing line with industrial robots and human operators. *Applied Sciences*, Vol. 10, Issue 8, 2862. DOI: https://doi.org/10.3390/app10082862.

18. Fu, M., Hao, Y., Gao, Z., Chen, X., Liu, X. (2022) User-Driven: A Product Innovation Design Method for a Digital Twin Combined with Flow Function Analysis. *Processes*, Vol. 10, Issue 11, 2353. DOI: https://doi.org/10.3390/pr10112353.

19. Khan, A.R., Yasin, A., Usman, S.M., Hussain, S., Khalid, S., Ullah, S.S. (2022) Exploring Lightweight Deep Learning Solution for Malware Detection in IoT Constraint Environment. *Electronics*, Vol. 11, Issue 24, 4147. DOI: https://doi.org/10.3390/electronics11244147.

20. Tsyokhla, S. Yu., Simchenko, N.A., Moiseenko, V.A. (2020) Network design of introduction of digital twins in industry [Setevoe proektirovanie vnedreniya cifrovyh dvojnikov v promyshlennosti]. *Bulletin of the north caucasian federal university [Vestnik Severo-Kavkazskogo federalnogo universiteta]*, No. 3, 106–112. DOI: https://doi.org/10.37493/2307–907X.2020.3.12. (In Russ.).

21. Ilyina, T.A., Kirina, D.N. (2020) Digitalization of logistics processes of Russian enterprises based on the introduction of RFID technology [Cifrovizaciya logisticheskih processov rossijskih predpriyatij na osnove vnedreniya tekhnologii RFID]. *St. Petersburg State Polytechnical University Journal. Economics [Nauchno-tekhnicheskie vedomosti SPbGPU. Ekonomicheskie nauki]*, Vol. 13, No. 4, 36–45. DOI: https://doi.org/10.18721/JE.13403. (In Russ.).

22. Sterman, J.D. (2000) *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston, Irwin McGraw-Hill.

23. Bencsik, A., Hargitai D. M., Kulachinskaya A. (2022). Trust in and Risk of Technology in Organizational Digitalization. *Risks*, Vol. 10, Issue 5, 90. DOI: https://doi.org/10.3390/risks10050090.

24. Ragulina, J.V., Ukolov, V.F., Shabunevich, O.V. (2021) Adaptation to the Risks of Digitalization: New Survival Trends for States in a Multipolar World. *Risks*, Vol. 9, Issue 12, 218. DOI: https://doi.org/10.3390/risks9120218.

25. Kazakov, S., Jordanova, J. (2017) Typology of risks in RFID. *Journal Scientific and Applied Research*, Vol. 12, 40–52.

26. McGrane, V., McDermott, O., Trubetskaya, A., Rosa, A., Sony, M. (2022) The Effect of Medical Device Regulations on Deploying a Lean Six Sigma Project. *Processes*, Vol. 10, Issue 11, 2303. DOI: https://doi.org/10.3390/pr10112303.

27. Maware, C., Parsley, D.M. (2022) The Challenges of Lean Transformation and Implementation in the Manufacturing Sector. *Sustainability*, Vol. 14, Issue 10, 6287. DOI: https://doi.org/10.3390/su14106287.

28. Baptista, A., Abreu, L., Brito, E. (2021) Application of lean tools: Case study in a textile company. *Proceedings on Engineering*, Vol. 3, Issue 1, 93–102. DOI: https://doi.org/10.24874/PES03.01.009.

29. Tripathi, V., Chattopadhyaya, S., Mukhopadhyay, A.K., Sharma, S., Li, C., Singh, S., Saleem, W., Salah, B., Mohamed, A. (2022) Recent Progression Developments on Process

Optimization Approach for Inherent Issues in Production Shop Floor Management for Industry 4.0. *Processes*, Vol. 10, Issue 8, 1587. DOI: https://doi.org/10.3390/pr10081587.

30. Akhtar, W.H., Watanabe, C., Tou, Y., Neittaanmäki, P.A. (2022) A New Perspective on the Textile and Apparel Industry in the Digital Transformation Era. *Textiles*, Vol. 2, Issue 4, 633–656. DOI: https://doi.org/10.3390/textiles2040037.

31. Lapshin, V.V., Smirnova, N.A. (2019) *Avtomatizirovannyi izmeritelnyi kompleks kak realizatsiia izmerenii tsifrovizatsii v legkoi promyshlennosti (Automated Measuring Complex as a Realization of the Concept of Digitalization in Garment Industry)*, Kostroma, Kostroma State University. Available at: https://www.elibrary.ru/item.asp?id=38515868. (In Russ.).

32. Küsters, D., Praß, N., Gloy, Y.S. (2017) Textile learning factory 4.0 –preparing Germany's textile industry for the digital future. *Procedia Manufacturing*, Vol. 9, 214–221. DOI: https://doi.org/10.1016/j.promfg.2017.04.035.

33. Darechkin, V.M. (2019) Vnedrenie iskusstvennogo intellekta v proizvodstvennyi tsikl ego predpriiatii legkoi promyshlennosti i sotsialno-ekonomicheskikh posledstvii [Implementation of artificial intelligence in the production cycle of garment industry enterprises and its socio-economic consequences]. Upravlenie kommertsiei ekonomiki: elektronnyi nauchnyi zhurnal [*Management of Economic Systems: Electronic Scientific Journal*], No. 4, 1–41, (in Russ.).

34. Maslova, O.P., Ilyina, T.A., Krichmar, V.A., Safronov, E.G. (2021) Implementing Lean Manufacturing and Solving Motivation Problems in Russian Companies. *In: Engineering Economics: Decisions and Solutions from Eurasian Perspective. International Scientific and Practical Conference*. Lecture Notes in Networks and Systems, Vol. 139, 384–391. DOI: https://doi.org/10.1007/978-3-030-53277-2_46.

35. Prasad, M.M., Dhiyaneswari, J.M., Jamaan, J.R., Mythreyan, S., Sutharsan, S.M. (2020) A framework for lean manufac-turing implementation in Indian textile industry. *Materials Today: Proceedings*. Vol. 33, Part 7, 2986–2995. DOI: https://doi.org/10.1016/j.matpr.2020.02.979.

36. Chen, Z., Xing, M (2015) Upgrading of textile manufacturing based on Industry 4.0. *5th International Conference on Advanced Design and Manufacturing Engineering*. Atlantis Press, 2143–2146. DOI: https://doi.org/10.2991/icadme-15.2015.400.

INFORMATION ABOUT AUTHORS

Tatiana Yurievna Kudryavtseva
Doctor of Economics, Professor, Graduate School of Industrial Economics, Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia (194064, Saint-Petersburg, Polytechnic street, 29); ORCID 0000-0003-1403-3447; e-mail: kudryavtseva_tyu@spbstu.ru.

Ksenia Sergeevna Kozhina
Assistant, Graduate School of Industrial Economics, Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia (194064, Saint-Petersburg, Polytechnic street, 29); ORCID 0000-0003-0877-1400; e-mail: kozhina_ks@spbstu.ru.

Gunnar Klaus Prause
Doctor of Economics, Professor for International Business, Tallinn School of Economics and Business Administration (TSEBA), Tallinn University of Technology, Tallinn, Estonia (Ehitajate tee 5, 12616 Tallinn); ORCID 0000-0002-3293-1331; e-mail: gunnar.prause@taltech.ee.

Eunice Omolola Olaniyi
Postdoctoral Research Fellow, Department of Geography and Geology, University of Turku, Turku, Finland (University of Turku, Turku, 20014, Finland); ORCID 0000-0002-2181-9328; e-mail: eoolan@utu.fi.

ACKNOWLEDGMENTS

The research is partially funded by the Ministry of Science and Higher Education of the Russian Federation under the strategic academic leadership program 'Priority 2030' (Agreement 075-15-2021-1333 dated 30.09.2021).

FOR CITATION

Kudryavtseva, T. Yu., Kozhina, K.S., Prause, G.K., Olaniyi, E.O. (2023). Assessment of Economic Efficiency, Effects and Risks of Digitalization Projects of Garment Industry in Russia. *Journal of Applied Economic Research*, Vol. 22, No. 1, 72–98. https://doi.org/10.15826/vestnik.2023.22.1.004.

ARTICLE INFO

Received October 13, 2022; Revised November 2, 2022; Accepted January 10, 2023.

УДК 338.45

Оценка экономической эффективности, эффектов и рисков проекта по цифровизации текстильной промышленности России

***Т. Ю. Кудрявцева*[1], *К. С. Кожина*[1] ✉, *Г. К. Праузе*[2], *Ю. О. Оланийи*[3]**

[1] *Санкт-Петербургский политехнический университет Петра Великого, г. Санкт-Петербург, Россия,*

[2] *Таллиннский технический университет, г. Таллинн, Эстония,*

[3] *Университет Турку, г. Турку, Финляндия*

✉ *kozhina_ks@spbstu.ru*

Аннотация. Для повышения эффективности производства на промышленных предприятиях в последнее время применяют различные цифровые технологии, которые имеют различный эффект: сокращение времени, материальных затрат, сокращение производственного цикла, рост производительности труда. Это исследование направлено на анализ и оценку эффективности цифровизации швейного производства, определение последствий и рисков проекта цифровизации. Проект цифровизации осуществлялся с использованием технологии радиочастотной идентификации (RFID) для мониторинга последовательных процессов изготовления одежды. В данном исследовании проверяется гипотеза о том, что использование цифровых технологий приводит к сокращению потерь времени и повышению производительности труда. В ходе исследования измерялось время производственного процесса. Далее рассчитывается возможное снижение потерь времени за счет внедрения цифровых технологий в условиях существующих производственных мощностей. Временные потери были использованы для дополнительной добычи, что приводит к изменению денежных потоков компании. В результате были рассчитаны показатели эффективности инвестиционного проекта, а его риски оценены с использованием анализа чувствительности. Теоретическая значимость заключается в определении экономических показателей, на которые влияет внедрение цифровых технологий в швейной промышленности. Внедрение технологии RFID дает возможность контролировать параметры производственного процесса, что позволило сократить потери времени на 50 %, снизить трудоемкость изделия и повысить производительность труда персонала предприятия на 30 %. Реализация проектов цифровизации несет в себе риски для компаний. Одним из них является риск недостижения цели по производительности труда. Также существует риск низкого спроса на дополнительный выпуск товаров. Чтобы свести к минимуму возможные риски, которые могут возникнуть, были предложены устойчивые смягчающие решения.

Ключевые слова: текстильная промышленность; цифровые технологии; умное производство; Индустрия 4.0; оценка рисков; устойчивое развитие; экономическая эффективность; инвестиционный анализ.

Список использованных источников

1. *Kagermann H., Helbig J., Hellinger A., Wahlster W.* Securing the future of German manufacturing industry // Final Report of the INDUSTRIE4.0: Working Group. Berlin; Frankfurt, 2013.

2. *Prause G.* Sustainable business models and structures for industry 4.0 // Journal of Security and Sustainability Issues. 2015. Vol. 5, Issue 2. Pp. 159–169. DOI: https://doi.org/10.9770/jssi.2015.5.2(3).

3. *Tjahjono B., Esplugues C., Ares E., Pelaez G.* What does industry 4.0 mean to supply chain? // Procedia manufacturing. 2017. Vol. 13. Pp. 1175–1182. DOI: https://doi.org/10.1016/j.promfg.2017.09.191.

4. *Vrana J., Singh R.* Digitization, digitalization, and digital transformation // Handbook of Nondestructive Evaluation 4.0. Springer, Cham., 2021. Pp. 1–17. DOI: https://doi.org/10.1007/978-3-030-48200-8_39–1.

5. *Denuwara N., Maijala J., Hakovirta M.* Sustainability benefits of RFID technology in the apparel industry // Sustainability. 2019. Vol. 11, Issue 22. P. 6477. DOI: https://doi.org/10.3390/su11226477.

6. *Ali A., Haseeb M.* Radio frequency identification (RFID) technology as a strategic tool towards higher performance of supply chain operations in textile and apparel industry of Malaysia // Uncertain Supply Chain Management. 2019. Vol. 7, Issue 2. Pp. 215–226. DOI: https://doi.org/10.5267/j.uscm.2018.10.004.

7. *Choi T. M., Yeung W., Cheng T. C., Yue X.* Optimal scheduling, coordination, and the value of RFID technology in garment manufacturing supply chains // IEEE Transactions on Engineering Management. 2017. Vol. 65, Issue 1. Pp. 72–84. DOI: https://doi.org/10.1109/TEM.2017.2739799.

8. *Chanchaichujit J., Balasubramanian S., Charmaine N. S. M.* A systematic literature review on the benefit-drivers of RFID implementation in supply chains and its impact on organizational competitive advantage // Cogent Business & Management. 2020. Vol. 7, Issue 1. P. 1818408. DOI: https://doi.org/10.1080/23311975.2020.1818408.

9. *Степанова Д. И.* Цифровые технологии управления бизнесом в производстве и текстильной промышленности России // Дизайн, технологии и инновации в текстильной и массовой промышленности (ИННОВАЦИИ-2018). Часть 3. М.: Российский государственный университет имени А. Н. Косыгина (Технологии. Дизайн. Искусство), 2018. С. 263–266. URL: https://elibrary.ru/item.asp?edn=ywsgzf&ysclid=le28kpdp9a115774001.

10. *Wong W. K., Guo Z. X.* Fashion Supply Chain Management Using Radio Frequency Identification (RFID) Technologies. Woodhead Publishing, 2014. DOI: https://doi.org/10.1016/B978-0-85709-805-4.50012–2.

11. *Veugelers R. (Eds).* Manufacturing Europe's future // Bruegel Blueprint Series. Vol. XXI, Brussels. 2013. URL: https://www.bruegel.org/sites/default/files/wp-content/uploads/imported/publications/Blueprint_XXI_web_181113a.pdf.

12. *Prause G., Atari S.* On sustainable production networks for Industry 4.0 // Journal of Entrepreneurship and Sustaibility Issues. 2017. Vol. 4, Issue 4. Pp. 421–431. DOI: https://doi.org/10.9770/jesi.2017.4.4(2).DOI: 10.9770/jesi.2017.4.4(2).

13. *Fritzsche A., Gölzer P.* Indutrial Applications of Artificial Intelligence: From Grand Stories of Digital Disruption to Actual Progress // Procedia CIRP. 2021. Vol. 104. Pp. 683–688. DOI: https://doi.org/10.1016/j.procir.2021.11.115.

14. *Shan S., Wen X., Wei Y., Wang Z., Chen Y.* Intelligent manufacturing in industry 4.0: A case study of Sany heavy industry // Systems Research and Behavioral Science. 2020. Vol. 37, Issue 4. Pp. 679–690. DOI: https://doi.org/10.1002/sres.2709.

15. *Jones E. C., Riley M. W., Franca R., Reigle S.* Case study: the engineering economics of RFID in specialized manufacturing // The Engineering Economist. 2007. Vol. 52, Issue 3. Pp. 285–303. DOI: https://doi.org/10.1080/00137910701503951.

16. *Iluore O. E., Mamudu Onose A., Emetere M.* Development of asset management model using real-time equipment monitoring (RTEM): case study of an industrial company // Cogent Business & Management. 2020. Vol. 7, Issue 1. P. 1763649. DOI: https://doi.org/10.1080/23311975.2020.1763649.

17. *Barosz P., Gołda G., Kampa A.* Efficiency analysis of manufacturing line with industrial robots and human operators // Applied Sciences. 2020. Vol. 10, Issue 8. P. 2862. DOI: https://doi.org/10.3390/app10082862.

18. *Fu M., Hao Y., Gao Z., Chen X., Liu X.* User-Driven: A Product Innovation Design Method for a Digital Twin Combined with Flow Function Analysis // Processes. 2022. Vol. 10, Issue 11. P. 2353. DOI: https://doi.org/10.3390/pr10112353.

19. *Khan A. R., Yasin A., Usman S. M., Hussain S., Khalid S., Ullah S. S.* Exploring Lightweight Deep Learning Solution for Malware Detection in IoT Constraint Environment // Electronics. 2022. Vol. 11, Issue 24. P. 4147. DOI: https://doi.org/10.3390/electronics11244147.

20. *Цёхла С. Ю., Симченко Н. А., Моисеенко В. А.* Сетевое проектирование внедрения цифровых двойников в промышленности // Вестник Северо-Кавказского федерального университета. 2020. № 3. С. 106–112. DOI: https://doi.org/10.37493/2307–907X.2020.3.12.

21. *Ильина Т. А., Кирина Д. Н.* Цифровизация логистических процессов российских предприятий на основе внедрения технологии RFID // Научно-технические ведомости СПбГПУ. Экономические науки. 2020. Т. 13, № 4. С. 36–45. DOI: https://doi.org/10.18721/JE.13403.

22. *Sterman J. D.* Business Dynamics: Systems Thinking and Modeling for a Complex World. Boston: Irwin McGraw-Hill, 2000.

23. *Bencsik A., Hargitai D. M., Kulachinskaya A.* Trust in and Risk of Technology in Organizational Digitalization // Risks. 2022. Vol. 10, Issue 5. P. 90. DOI: https://doi.org/10.3390/risks10050090.

24. *Ragulina J. V., Ukolov V. F., Shabunevich O. V.* Adaptation to the Risks of Digitalization: New Survival Trends for States in a Multipolar World // Risks. 2021. Vol. 9, Issue 12. P. 218. DOI: https://doi.org/10.3390/risks9120218.

25. *Kazakov S., Jordanova J.* Typology of risks in RFID // Journal Scientific and Applied Research. 2017. Vol. 12. Pp. 40–52.

26. *McGrane V., McDermott O., Trubetskaya A., Rosa A., Sony M.* The Effect of Medical Device Regulations on Deploying a Lean Six Sigma Project // Processes. 2022. Vol. 10, Issue 11. P. 2303. DOI: https://doi.org/10.3390/pr10112303.

27. *Maware C., Parsley D. M.* The Challenges of Lean Transformation and Implementation in the Manufacturing Sector // Sustainability. 2022. Vol. 14, Issue 10. P. 6287. DOI: https://doi.org/10.3390/su14106287.

28. *Baptista A., Abreu L., Brito E.* Application of lean tools: Case study in a textile company // Proceedings on Engineering. 2021. Vol. 3, Issue 1. Pp. 93–102. DOI: 10.24874/PES03.01.009.

29. *Tripathi V., Chattopadhyaya S., Mukhopadhyay A. K., Sharma S., Li C., Singh S., Saleem W., Salah B., Mohamed A.* Recent Progression Developments on Process Optimization Approach for Inherent Issues in Production Shop Floor Management for Industry 4.0 // Processes. 2022. Vol. 10, Issue 8. P. 1587. DOI: https://doi.org/10.3390/pr10081587.

30. *Akhtar W. H., Watanabe C., Tou Y., Neittaanmäki P. A.* A New Perspective on the Textile and Apparel Industry in the Digital Transformation Era // Textiles. 2022. Vol. 2, Issue 4. Pp. 633–656. DOI: https://doi.org/10.3390/textiles2040037.

31. *Лапшин В. В., Смирнова Н. А.* Автоматизированный измерительный комплекс как реализация измерений цифровизации в легкой промышленности. Кострома: Костромской государственный университет, 2019. URL: https://www.elibrary.ru/item.asp?id=38515868.

32. *Küsters D., Praß N., Gloy Y. S.* Textile learning factory 4.0–preparing Germany's textile industry for the digital future // Procedia Manufacturing. 2017. Vol. 9. Pp. 214–221. DOI: https://doi.org/10.1016/j.promfg.2017.04.035.

33. *Даречкин В. М.* Внедрение искусственного интеллекта в производственный цикл его предприятий легкой промышленности и социально-экономических последствий // Управление коммерцией экономики: электронный научный журнал. 2019. № .4 (122). URL: https://www.elibrary.ru/item.asp?id=39788243.

34. *Maslova O. P., Ilyina T. A., Krichmar V. A., Safronov E. G.* Implementing Lean Manufacturing and Solving Motivation Problems in Russian Companies // Engineering Economics: Decisions and Solutions from Eurasian Perspective. International Scientific and Practical Conference. Lecture Notes in Networks and Systems. Vol. 139. Pp. 384–391. DOI: https://doi.org/10.1007/978-3-030-53277-2_46.

35. *Prasad M. M., Dhiyaneswari J, Jamaan J. R., Mythreyan S., Sutharsan S. M.* A framework for lean manufac-turing implementation in Indian textile industry // Materials Today: Proceedings. 2020. Vol. 33. Pp. 2986–2995. DOI: https://doi.org/10.1016/j.matpr.2020.02.979.

36. *Chen Z., Xing M.* Upgrading of textile manufacturing based on Industry 4.0 // 5th International Conference on Advanced Design and Manufacturing Engineering. Atlantis Press, 2015. Pp. 2143–2146. DOI: https://doi.org/10.2991/icadme-15.2015.400.

ИНФОРМАЦИЯ ОБ АВТОРАХ

Кудрявцева Татьяна Юрьевна
Доктор экономичнских наук, доцент, профессор Высшей инженерно-экономической школы Санкт-Петербургского политехнического унивеститета Петра Великого, г. Санкт-Петербург, Россия (194064, г. Санкт-Петербург, ул. Политехническая, 29); ORCID 0000-0003-1403-3447; e-mail: kudryavtseva_tyu@spbstu.ru

Кожина Ксения Сергеевна
Ассистент Высшей инженерно-экономической школы, Санкт-Петербургского политехнического унивеститета Петра Великого, г. Санкт-Петербург, Россия (194064, г. Санкт-Петербург, ул. Политехническая, 29); ORCID 0000-0003-0877-1400; e-mail: kozhina_ks@spbstu.ru.

Праузе Гуннар Клаус
Доктор экономических наук, профессор международного бизнеса Таллиннской школы экономики и делового администрирования Таллиннского технического университета, г. Таллинн, Эстония (Ehitajatetee 5, 12616 Tallinn); ORCID 0000-0002-3293-1331; e-mail: gunnar.prause@taltech.ee.

Оланийи Юнис Омолола
Постдокторский научный сотрудник кафедры географии и геологии Университета Турку, г. Турку, Финляндия (Турку, 20014, Финляндия); ORCID 0000-0002-2181-9328; e-mail: eoolan@utu.fi.

БЛАГОДАРНОСТИ

Исследование частично финансируется Министерством науки и высшего образования Российской Федерации в рамках программы стратегического научного лидерства «Приоритет 2030» (Договор 075-15-2021-1333 от 30.09.2021).

ДЛЯ ЦИТИРОВАНИЯ

Кудрявцева Т. Ю., Кожина К. С., Праузе Г. К., Оланийи Ю. О. Оценка экономической эффективности, эффектов и рисков проекта по цифровизации текстильной промышленности России // Journal of Applied Economic Research. 2023. Т. 22, № 1. С. 72–98. https://doi.org/10.15826/vestnik.2023.22.1.004.

ИНФОРМАЦИЯ О СТАТЬЕ

Дата поступления 13 октября 2022 г.; дата поступления после рецензирования 2 ноября 2022 г.; дата принятия к печати 10 января 2023 г.