

Digitalization Modeling of Production Processes in Paper Packaging Sector Companies

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ABSTRACT

As the production process technologies in the paper packaging industry evolve and improve, new opportunities emerge for companies in this sector to achieve greater efficiency. These include new ways to reduce employee workload, optimize business processes, ensure packaging quality, and improve maintenance procedures for production equipment, among others. Paper packaging manufacturing companies aiming to improve operational efficiency and maintain market leadership while aligning with the goals of the European industrial strategy must focus on new, rapidly developing digitalization technologies for paper packaging production and their effective implementation. Therefore, this study aimed to identify the directions of digitalization in companies' production processes in the paper packaging sector. Research methods, such as a review of scientific studies and expert evaluation (in-depth interviews) in the paper packaging sector, were applied in this research. The results showed that experts are confident in the benefits of digitalizing paper packaging production equipment to enhance company efficiency. However, one of the main barriers identified is the lack of funding.

Keywords: digitalization, production processes, digitalization modeling of production processes, paper packaging sector.

1. Introduction

Lithuanian industrial policy is based on the European Commission's new industrial strategy for Europe (2021), which outlines three key development priorities: maintaining the global competitiveness of European industry and ensuring a level playing field both within the EU and globally; making Europe climate-neutral by 2050; and shaping Europe's digital future. The goal of Lithuania's Industrial Digitalization Roadmap 2030 (2022) is to ensure the international competitiveness of Lithuania's industry and to establish the country as a leader in industrial digitalization within the geographical space that includes Lithuania, Latvia, Estonia, and Northern Poland, while also aiming to catch up with Finland, Sweden, and Denmark. As the production process technologies in paper packaging companies evolve and improve, new opportunities arise within the packaging sector to achieve greater efficiency. These include new ways to reduce employee workload, streamline and optimize processes, ensure high packaging quality, and enhance the maintenance procedures for production equipment. In Lithuania, the labor productivity per person in industrial companies that have implemented innovations (€36,100) is more than twice as high compared to companies that have not adopted innovations (€17,900) (Official Statistics Portal, 2020). Paper packaging manufacturing companies seeking to improve their performance indicators, maintain competitiveness, and align with the goals of the European industrial strategy and Lithuania's Industrial Digitalization Roadmap 2030 must take into account the new, rapidly evolving digitalization technologies in paper packaging production and their effective implementation. This study aims to identify the directions of digitalization in the production processes of paper packaging sector companies. In order to achieve this goal, the

following objectives were set: to evaluate why the production processes of paper packaging companies need to be digitalized using the latest digitalization technologies; to conduct a needs analysis of the production processes in paper packaging companies, applying an expert assessment method; and to assess which digitalization technologies for production processes would help increase the efficiency of paper packaging sector companies. The main research methods employed were analysis of scientific literature, expert evaluation from the paper packaging sector, and in-depth interviews.

2. Digital Business Transformation Peculiarities

Guided by recognized opportunities, identified changes, needs, intentions, and goals for development in the digital age, companies begin their transformation, known as digital transformation, aiming for competitive advantage and emphasizing diversity (Fernández-Rovira & Álvarez Valdés, 2021; Skhiri & Duverne, 2020). Digital business transformation is becoming a key objective for every company (Karekla et al., 2021). Li (2020) defines digital transformation as a modern approach to overcoming the barriers caused by digital changes.

Each company has its perspective and follows a different path on its digital journey (Karekla et al., 2021). Ochara et al. (2018) also mention business process modeling, which is business process management, as a critical aspect of digital transformation. Boguea Gomes et al. (2019) note that most innovations are driven by processes rather than technology. Brkic et al. (2020) argue that technology is one of the driving forces behind business changes. Changes in the global market impact organizational changes, meaning that companies must adapt quickly to new conditions to thrive in the market.

Companies can keep up with global trends by changing their business processes (Stjepić et al., 2020). Due to the importance of business processes, their monitoring and effective management are crucial for a company's success (Stjepić et al., 2020). Kreuzer et al. (2022) argue that recognizing the opportunities of digital technologies is essential in today's digital world. Therefore, digital transformation is increasingly becoming a core issue for companies worldwide (Thamjaroenporn and Achalakul, 2021).

The key technologies that are disrupting markets and opening new opportunities to transform strategies and operations in ways we could not have imagined just a few years ago are as follows: cloud computing (Wessel et al., 2021), the Internet of Things (IoT), big data, artificial intelligence (AI) (Favoretto et al., 2022; Gurbaxani & Dunkle, 2019; Karekla et al., 2021; Khin & Ho, 2019; Li, 2020; Pînzaru et al., 2019), blockchain, and robotics (Karekla et al., 2021).

Although digital transformation is based on digital technologies, it is a much broader concept that encompasses business analysis and process reengineering, changes in strategies, organizational structure, management approaches, employee motivation, and the knowledge and skills required by employees to adapt to these changes. This aligns with the evolving digital business contexts (Favoretto et al., 2022; Gurbaxani et al. & Dunkle, 2019).

Stoyanova (2020) considers that the digitalization process improves business models, work efficiency, innovation, and the quality of management decisions, reducing costs, increasing company visibility and communication, putting the customer in the center of activities, and many other positive effects are the benefits that organizations receive.

The organization's digital transformation will have the effect of developing the organization sustainably. Thus, organizations can adopt ecological and sustainable approaches by reducing waste. The main benefits of the sustainable transformation of the organization can be (Barna et al., 2023):

- reducing paper, carbon footprints, and waste;
- faster and more efficient processes that use fewer resources.

There are three orders in digital/human transformation (convergent change, work transformation, and organizational transformation) (Baptista et al., 2020).

3. Analysis of Digitalization Trends in Production Processes of Companies in the Paper Packaging Sector

Expert evaluation is a process where qualified specialists or experts analyze and assess specific information, products, or services based on their deep knowledge and experience in a particular field. Therefore, high-quality and professional evaluation results can be expected (Macijauskienė et al., 2023).

In order to model the digitalization of production processes, an expert evaluation was conducted between the main users and technology developers, using in-depth interviews with a structured questionnaire. The interviewed experts (who meet the competency and experience requirements for this field of work) included:

Nine experts from the paper packaging sector were selected, with work experience ranging from 9 to 24 years. Their positions included roles such as Company Director, Production Manager, Technical Manager, Technology Development Manager, Design Manager, Chief Service Engineer, and Key Account Manager.

The experts were presented with 8 questions related to the digitalization of production processes in the paper packaging sector, aiming to identify which digitalization opportunities are relevant and what benefits and risks experts perceive in digitalization projects:

- What digitalization opportunities do you see in the paper packaging production processes?
- What factors hinder the digitalization of production processes in paper packaging manufacturing companies?
- What risks do you perceive when implementing process digitalization solutions in production?
- Do you consider your company's production processes to be more digitalized than those of your main competitors?
- Are there any new production digitalization projects currently underway in your company?
- Is digitalization included in your company's strategic objectives?
- Which digitalization opportunities in production processes would yield the greatest impact and should be prioritized?

On a scale of 1 to 5 (where 1 = poor, 5 = excellent), how would you rate the importance of the following factors for the success of digital transformation?

- a) Return on investment within <3 years;
- b) Reduced number of employees;
- c) Increased equipment efficiency;
- d) Improved information visibility and accessibility;
- e) Timely order fulfillment;

f) Increased equipment reliability.

4. Research Results

The expert evaluation revealed which areas of paper packaging production processes can be digitalized. During the study, the following aspects were assessed:

- Digitalization opportunities in paper packaging production processes;
- Barriers to the digitalization of production processes in paper packaging manufacturing companies;
- Risks associated with implementing digitalization solutions in production;
- Comparison of digitalization levels with main competitors;
- Ongoing new production digitalization projects;
- The importance of digitalization in the company's strategic objectives;
- Priority digitalization opportunities that would yield the greatest impact;
- Success factors for digital transformation.

These aspects provided valuable insights into the current state of digitalization in the sector and potential areas for improvement and focus.

The results of the study showed that the main barriers to digitalizing production processes in paper packaging manufacturing companies are funding and time constraints. Key risks identified in implementing digitalization solutions in production include project delays, employee training, and knowledge acquisition issues.

A comparison of the digitalization levels of the companies evaluated with those of their main competitors in the region revealed that the digitalization level of the assessed companies is higher than that of their competitors. Regarding new production digitalization projects currently underway, only about one-third of experts mentioned that such initiatives and projects are taking place. When analyzing whether digitalization is one of the company's strategic objectives, only one-third of experts confirmed that digitalization is part of their company's strategic goals.

In assessing the priority digitalization opportunities that would yield the greatest impact, experts highlighted that the highest priority should be given to automation and robotics of production equipment, as well as the next-generation production management system with AI.

The study also identified the main success factors for digital transformation: reduced labor costs per unit of production and increased equipment efficiency (Table 1).

Table 1: Expert Evaluation of the Digitalization Process (Compiled by the author, based on the expert evaluation conducted through in-depth interviews)

Evaluated Aspects	Expert Evaluation Results
Opportunities for Digitalization in Paper Packaging Production Processes	The following digitalization opportunities were mentioned: Production management system with AI, Equipment automation and robotics, Packaging design modeling software, Maintenance systems, Raw materials and finished goods management software, Logistics software, and Employee training and development solutions (more detailed information in Figure 1).

Barriers to Digitalizing Production Processes in Paper Packaging Companies	88.8% of experts stated that funding is a barrier; 55.5% noted that it is time-consuming; 33.3% mentioned legacy systems and their complex integration (average rating in Figure 3).
Risks in Implementing Digitalization Solutions in Production	66.6% of experts indicated that such projects often face delays; 55.5% pointed out employee training and knowledge acquisition issues; and 33.3% mentioned vendor support and maintenance risks.
Comparison of Digitalization Level with Competitors	44.4% of experts stated that the digitalization level is higher than competitors; 33.3% said it is lower than competitors; 22.2% were uncertain or could not answer.
New Digitalization Projects Currently Underway	33.3% of experts said new projects are ongoing; 66.6% mentioned that no new projects are currently being implemented.
Digitalization as Part of the Company's Strategic Objectives	33.3% of experts confirmed that digitalization is part of the company's strategic goals; 55.5% stated it is not; 11.1% mentioned that the company has no strategic goals.
Priority Digitalization Opportunities with the Greatest Impact	77.7% of experts prioritized automation and robotics of production equipment. 66.6% mentioned the next-generation production management system with AI as a major priority, and 66.6% emphasized design modeling and maintenance solutions.
Key Success Factors for Digital Transformation	(1) Reduced labor costs per unit of production; (2) Increased equipment efficiency; (3) Growth in equipment reliability; (4) Return on investment within less than 3 years.

Table 1 shows that all experts mentioned equipment automation and robotics, as well as packaging design modeling software. 77.7% pointed out the production management system with AI, and 66.6% mentioned maintenance solutions, raw material and finished goods inventory and accounting software, as well as logistics and goods loading/completion modules. Additionally, 44.4% of experts referred to employee training online platforms.

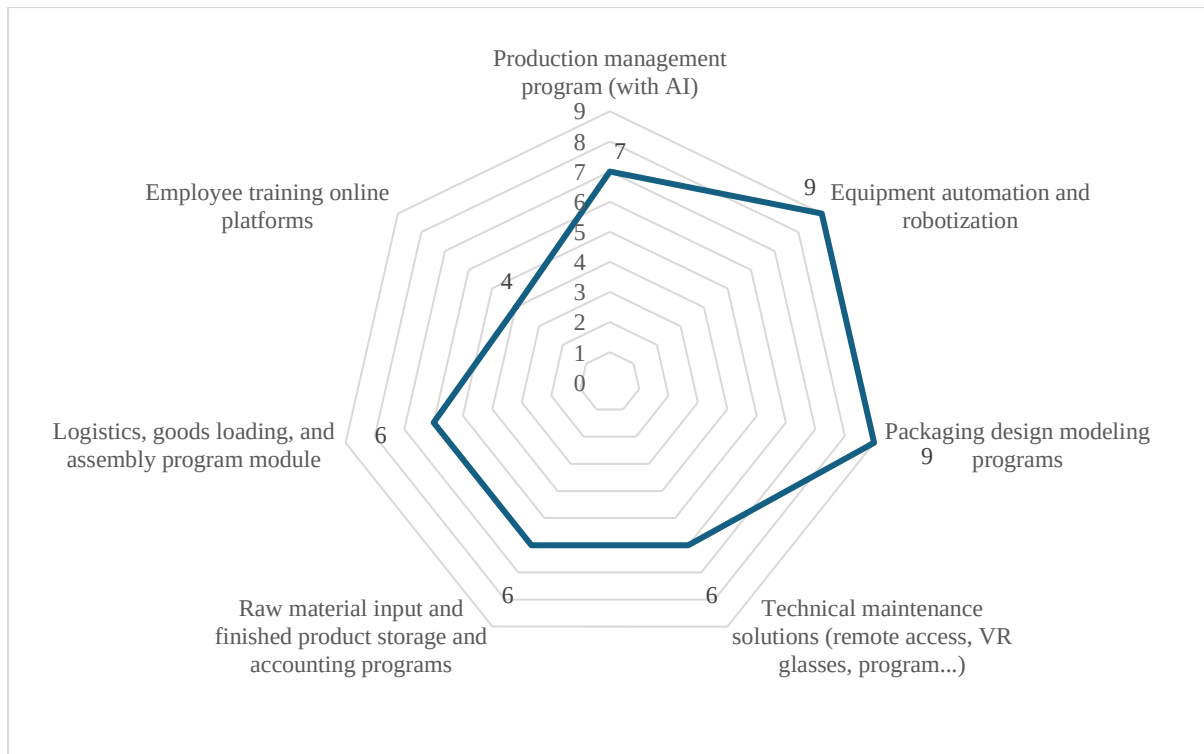


Figure 1: Main directions of production digitalization mentioned by experts (number of experts)
(compiled by the author)

Figure 2 shows the average ratings provided by the experts for the main benefits of production digitalization:

- Return on investment in less than 3 years (4.4 points);
- Reduced labor costs per unit of production (5 points);
- Increased equipment efficiency (4.7 points);
- Improved information visibility and accessibility (4.1 points);
- On-time order completion (3.8 points);
- Increased equipment reliability (4.6 points).

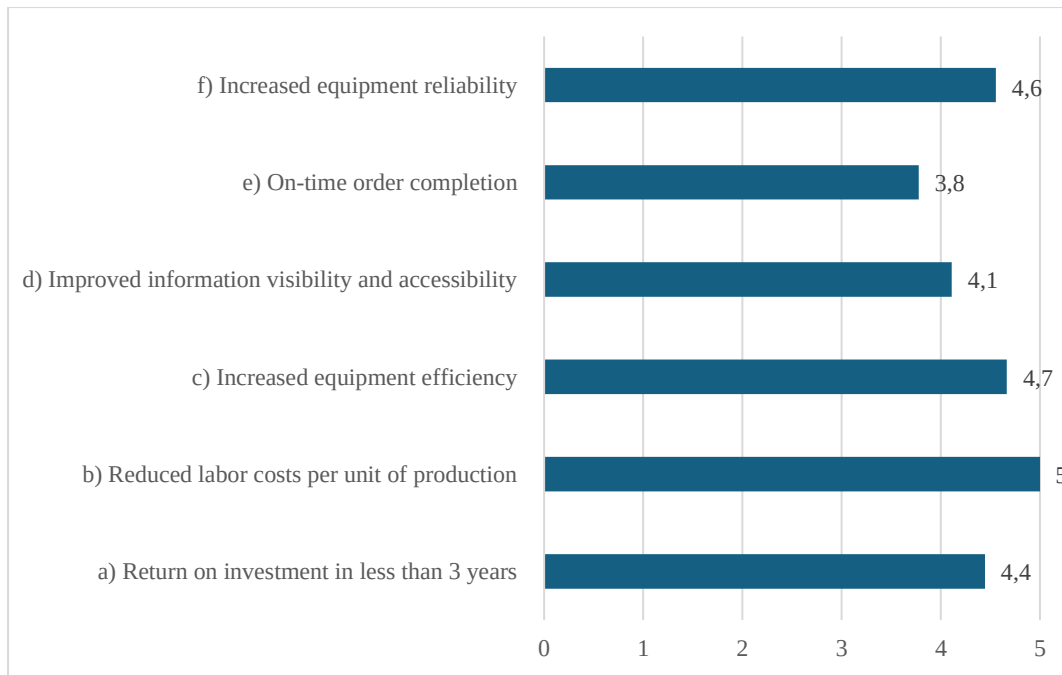


Figure 2: Expert averages of the main benefits of digitalization of production (compiled by the author)

Figure 3 illustrates the expert ratings for the main barriers to production digitalization, with the largest share attributed to funding (88.8%), followed by long implementation time (55.5%) and existing legacy systems and complex integration (33.3%). Smaller barriers include lack of vision (22.2%), lack of management support (22.2%), and mistakes with previous projects and lack of knowledge about new digitalization opportunities (both 11.1%).

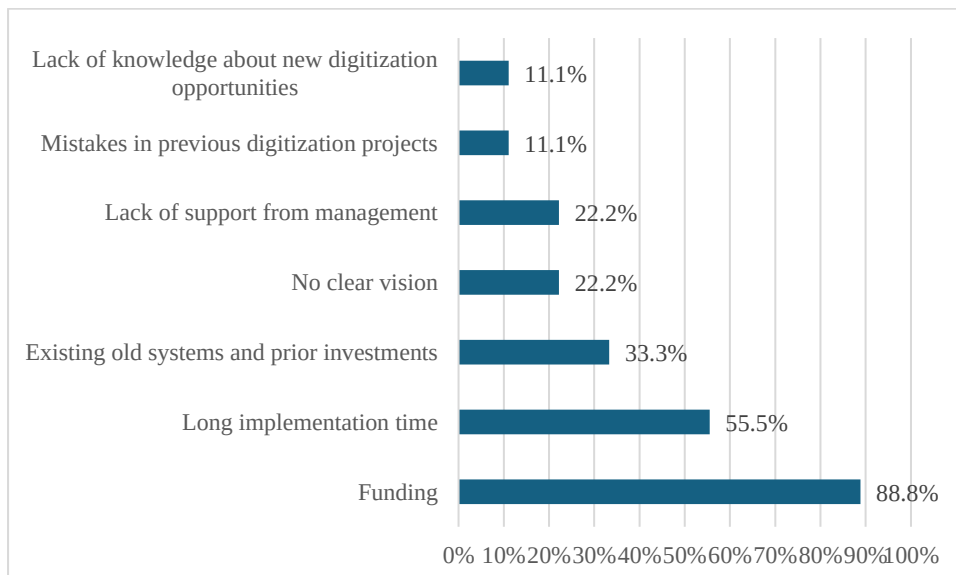


Figure 3: The main obstacles to the digitalization of production were assessed by experts' averages (compiled by the author)

The digitalization of paper packaging production processes with new technological solutions offers new opportunities to increase production efficiency. Automation and robotics can replace human labor at

physical workstations, thus not only saving (or maintaining) costs but also preventing production line speed from being limited by human fatigue. Production management software already incorporates artificial intelligence (AI), which handles intelligent production planning. The planner now only monitors deviations and responds to software alerts regarding schedule delays, excessive waste, insufficient raw material stocks, and other critical indicators. These systems integrate key modules, such as quality control, design, product technical sheet creation, customer pricing calculation, logistics, etc. Packaging design software allows users to convert blueprints into 3D models, enabling not only the validation of packaging functionality but also the ability to view the print positioning and the overall look of the future package from a 360-degree perspective. This feature benefits both designers and clients. The latest packaging production equipment is equipped with smart monitoring systems for motors and other components, remote access for the manufacturer, and provides alerts to the maintenance department about component overloads, potential upcoming failures, or required inspection points. Virtual reality (VR) goggles are used to visualize the device's structure, receive assembly instructions, and order necessary parts.

5. Conclusions

Smart production management software provides the ability to monitor data in detail, generate reports, and perform analyses that reduce labor costs, material costs, and overhead, enabling operational cost reductions of up to 12%. Process digitalization in production allows for increased revenue and boosts factory output by up to 30% while also shortening delivery times of manufactured packaging to customers, reducing batch sizes, and decreasing time-to-market (Emily Himes, 2023).

Given the importance of business processes, their monitoring and effective management are crucial to a company's success. Digitalizing production processes offers numerous opportunities to track performance indicators, streamline and simplify processes, save costs, remain competitive in the market, and better meet customer demands.

The expert evaluation revealed that experts strongly agreed with the benefits of digitalizing the production of paper packaging equipment to improve company efficiency. However, one of the main obstacles identified is the lack of funding. Nevertheless, there are numerous EU and Lithuanian support programs that encourage and finance digitalization projects. Therefore, it is crucial to seek more information and consult specialists from organizations such as LIC, LVPA, INVEGA, and others. Additionally, companies themselves need to invest, as investments in digitalization innovations quickly pay off.

The automation and robotization of paper packaging production equipment, along with production management software, packaging design modeling programs, and maintenance solutions, should be prioritized as digitalization solutions to achieve efficiency.

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