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THE EFFECT OF PACKING MACHINE AUTOMATION ON OPERATOR PRODUCTIVITY WITH MODERATION OF TECHNICAL COMPETENCE AND WORKLOAD PERCEPTION SYSTEMATIC LITERATURE REVIEW (SLR) WITH BIBLIOMETRICS

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Abstract

This study aims to analyze the influence of packing machine automation on operator productivity in the facial tissue industry by considering the role of moderation, technical competence and operator workload perception. The method used is Systematic Literature Review (SLR) by reviewing scientific articles published in the 2020–2026 range from reputable databases such as Scopus. The selection process was carried out using the PRISMA approach through the identification, screening, eligibility, and inclusion stages, resulting in a number of articles relevant to the topics of industrial automation, labor productivity, technical competence, and workload. The results of the study show that the implementation of packing machine automation in general has a positive impact on increasing operator productivity through time efficiency, quality consistency, and reduction of manual errors. Nevertheless, the effectiveness of automation is highly dependent on the level of technical competence of the operator, especially in the operation, maintenance and troubleshooting of the machine. In addition, workload perception has also been shown to moderate the relationship, where automation can lower physical workloads but potentially increase mental workloads due to the demands of automated system supervision. Other findings suggest that an imbalance between automation levels and human resource readiness can hinder productivity optimization. Conceptually, this study confirms that the relationship between packing machine automation and operator productivity is not linear, but is influenced by individual and psychological factors. The practical implications of this study are the importance of technical competency-based training as well as adaptive workload management in supporting the successful implementation of automation in the manufacturing industry. This research contributes to the development of an integrative model that connects technology, people, and operational performance in the context of the tissue processing industry.

Keywords: *machine automation, operator productivity, technical competence, workload, systematic literature review.*

1. INTRODUCTION

The development of the industrial revolution 4.0 has driven significant transformation in the manufacturing sector, especially through the application of automation in production lines. Machine automation, including in the packing process, is the main strategy in improving operational efficiency, quality consistency, and company productivity. Studies show that the integration of technologies such as intelligent automation and artificial intelligence is able to optimize production processes, reduce manual errors, and significantly increase output in various sectors of the manufacturing industry (Permana et al., 2025; Belmouadden et al., 2025). In the context of the tissue industry, especially facial tissue products, the packing process is a crucial stage that determines the speed of distribution and the quality of the final product, so that the application of automation is a strategic need to increase the competitiveness of the industry.

Nevertheless, the implementation of automation not only impacts the technical aspect, but also changes the role and work characteristics of the operator. Modern automation no longer simply replaces human labor in routine work, but also requires operators to interact with complex technology-based systems. This is in line with the concept of Operator 4.0, where workers are expected to be able to collaborate with machines, understand digital systems, and make data-driven decisions (Peruzzini & Pellicciari, 2020). This transformation shifts the role of the operator from a manual task executor to a supervisor and controller of the system, which directly affects the dynamics of work productivity.

A number of studies show that automation has a positive impact on labor productivity through increased time efficiency, reduced downtime, and optimization of resource use. For example, recent research shows that organizations that adopt automation are able to increase productivity by more than 40% as well as significantly reduce processing time (Pettersson, 2025). In addition, automation also contributes to improving product quality and operational sustainability through the reduction of waste and production errors (Karim et al., 2025). Thus, the automation of packing machines theoretically has great potential in increasing operator productivity in the manufacturing industry.

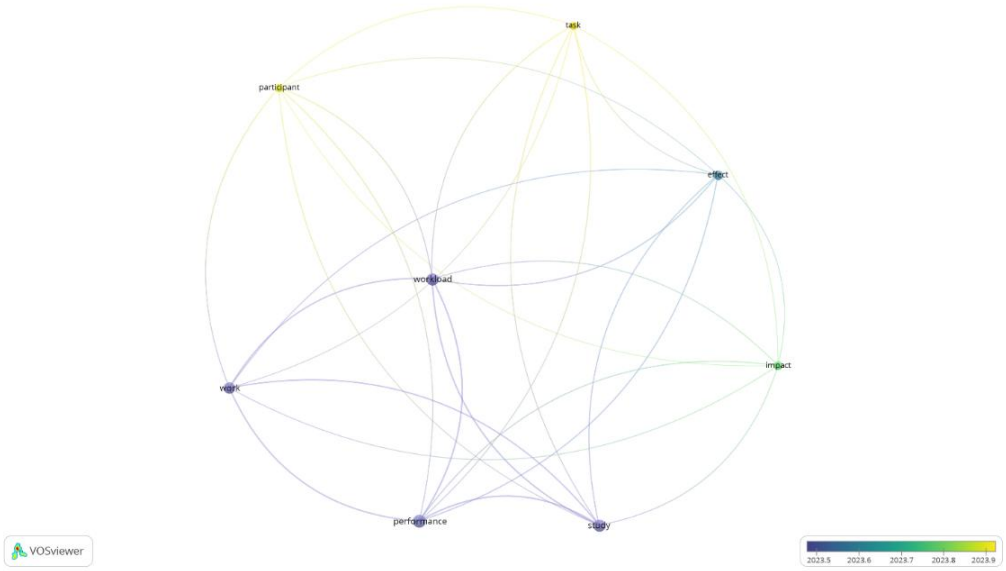
Nonetheless, the relationship between automation and productivity isn't always linear. Several studies show that the success of automation implementation is greatly influenced by human factors, especially the technical competence of operators. Lack of technical skills and understanding of automated systems can be a major obstacle in optimizing machine performance. Research shows that the skill gap is a major challenge in the implementation of automation, where operators who do not have adequate competencies tend to experience difficulties in the operation and maintenance of systems (Hu et al., 2024; Liu et al., 2024). On the contrary, improving technical competence has been proven to be

able to strengthen the positive impact of automation on organizational performance and productivity (Karim et al., 2025).

In addition to technical competence, psychological aspects such as workload perception are also important factors in determining the effectiveness of automation. Automation can indeed reduce the physical workload, but on the other hand it can increase the mental workload due to the demands of complex system supervision. Studies show that system complexity and human-machine interaction can increase cognitive workload, ultimately affecting operator performance (Peruzzini & Pellicciari, 2020). In fact, recent research reveals that workload imbalances can lead to work burnout that has an impact on decreased operator productivity (SITEKIN, 2024). This shows that workload perception is not only a consequence of automation, but also serves as a variable that moderates the relationship between technology and productivity.

Furthermore, the human-centered manufacturing approach emphasizes that the success of automation does not only depend on technology, but also on the integration between humans and systems. Research shows that the relationship between humans and technology is complementary, where humans remain important in decision-making and handling complex situations that cannot be fully automated (Garus & Greis, 2025). Therefore, an approach that focuses solely on technology without paying attention to human factors tends to result in suboptimal automation implementations.

Based on this description, there is a research gap related to how packing machine automation affects operator productivity by considering moderation factors such as technical competence and workload perception. Most previous research has still addressed automation in general without comprehensively integrating human factors in a single conceptual model. Therefore, this study uses the Systematic Literature Review (SLR) approach to systematically examine the relationship between packing machine automation, operator productivity, technical competence, and workload perception. This study is expected to make a theoretical contribution to the development of technology- and human-based integrative models, as well as provide practical implications for the manufacturing industry in optimizing the implementation of automation in a sustainable manner.



The visualization of the network overlay from VOSviewer shows a map of keyword linkages in the research that focuses on the relationship between workload, performance, and impact in the context of work and tasks. The "workload" node is seen in the central position, which indicates that this variable is the main focus and has a strong relationship with various other concepts such as "work", "performance", and "effect". This indicates that in the literature analyzed, workload is a key variable that is often used to explain individual performance variations. Meanwhile, the "performance" and "work" nodes are in relatively close clusters, showing a close relationship between work activities and the results of the performance produced. This interconnectedness reinforces the assumption that operator productivity is heavily influenced by how work is managed and executed.

On the other hand, nodes such as "task", "participant", and "study" show a linkage to the methodological aspects of research, indicating that many studies in this area use task- and participant-based approaches to measure workload and its impact on performance. The colors in the overlays (from blue to yellow) reflect temporal developments, where topics such as "performance" and "work" tend to appear earlier, while "task" and "participant" appear more often in recent research. This shows a shift in research focus from just a work-performance relationship to a more specific and experimental approach to measuring workload. In addition, the "impact" and "effect" nodes connected to various variables indicate that the research tends to be oriented towards causal relationship analysis.

Overall, this map indicates that research related to workload and performance continues to evolve with an increasingly complex and integrated approach. In the context of this study, these findings reinforce that workload perception is a highly relevant and strategic variable as a moderator in the relationship between automation and operator productivity, as it has a strong correlation both conceptually and empirically with various performance indicators.

2. RESEARCH METHOD

The Systematic Literature Review (SLR) method is used in this study, because this study aims to synthesize the existing literature to answer research questions related to machine automation, operator productivity, technical competence, and workload. Kraus et al. (2020) state that SLR is a form of research by synthesizing existing or published research with a systematic methodology. The systematic method is carried out based on several stages, namely by conducting a comprehensive search for published articles, then selection, and analysis of relevant studies. These stages follow the set guidelines. The PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) stage is used to identify existing literature. The stages of PRISMA set in this study are "Identification", "Screening" and "Included".

1) PRISMA Guidelines Steps

a. Identification

The identification stage includes determining search terms, search criteria, databases and data extraction methods. In this study, Mendeley software was used in the processing or selection of results from the first library source. Search for articles or journals with scopus library sources. The three performers are combined with the reason to know the trends and all types of articles are accepted. The keywords entered in each journal database are TITLE-ABS-KEY (perceived AND workload, AND work AND performance) AND PUBYEAR > 2019 AND PUBYEAR < 2027 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "SOCI")).

b. Screening

In this step, screening, retrieving, and assessing the feasibility of each article is carried out. Non-compliant articles will be eliminated, while compliant articles will be analyzed in accordance with Table 1.

Table 1. Article Screening Criteria

Inclusion Criteria	1. The results of the research in the perceived AND workload, AND work AND performance sectors. 2. Research results in the social sciences sector. 3. Location of article research in countries in the world 4. The year of publication of the article/journal is 2020 – 2026.

Exclusion Criteria	1.	Conceptual article or review/*litelature review*
	2.	Accessible articles.

The inclusion criteria in this study ensure that the selected articles are relevant to the topics of perceived workload, work, and performance, focus on the field of social sciences, cover a global context, and come from the latest publication (2020–2026). This is so that the analysis reflects current conditions and has a variety of research contexts. Meanwhile, the exclusion criteria emphasizes the elimination of conceptual articles and literature review so that SLR results are based on empirical data. However, the point related to "accessible articles" needs to be clarified, because methodologically what should be excluded is an article that does not have full access. Overall, these criteria support the quality and validity of the study results.

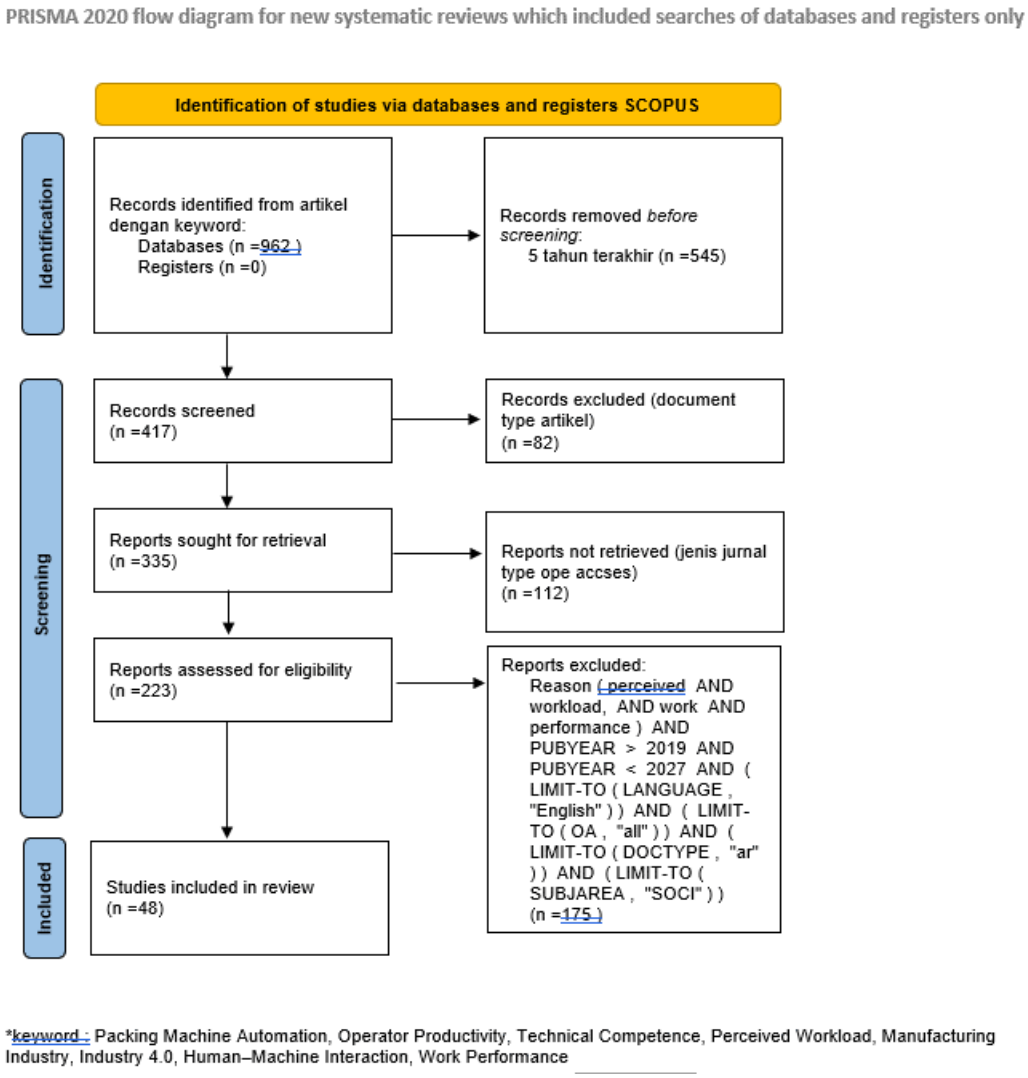
c. Included

The next step is inclusion. Article entry is done manually. The researcher selects articles that are filtered by keywords. The selection was made because the search results with keywords in the journal database still contained articles that did not contain or were in accordance with the screening criteria. Priyashantha et al. (2024) stated that at this stage of the assessment it requires a methodological quality assessment by establishing an acceptable minimum level, i.e. meeting the inclusion criteria, while articles that do not meet the inclusion are not analyzed or removed from the list. The PRISMA 2020 diagram describes the process of selecting articles in the Systematic Literature Review (SLR) in a systematic and transparent manner. At the identification stage, a total of 962 articles were found from the Scopus database based on relevant keywords. Furthermore, a total of 545 articles were eliminated because they did not meet the criteria for the year of publication (outside the range of the last 5 years), leaving 417 articles for the initial screening stage. At the screening stage, as many as 82 articles were issued because they did not match the type of document they wanted, so that 335 articles were obtained that entered the search stage for complete documents. However, a total of 112 articles are not accessible (non-open access), so only 223 articles can be further evaluated at the eligibility stage.

At the eligibility level, a stricter selection is carried out based on the suitability of the topic, language, field of knowledge, and type of document. A total of 175 articles were eliminated because they did not meet criteria such as being irrelevant to the variables of perceived workload, work, and performance, or not included in the field of social sciences. Finally, 48 articles were obtained that met all the criteria and were used in the SLR analysis. This process shows that out of a large initial number, only a small fraction of the articles are truly relevant and of quality for further analysis. This confirms that the use of the PRISMA method is able to increase validity, reliability, and transparency in the selection of research literature.

Finally, a total of 48 articles were declared to meet all inclusion criteria and included in a systematic review. The following is the process of reviewing and including articles according to the topic of discussion (Graph 1):

Graph 1. PRISMA Article Filtering



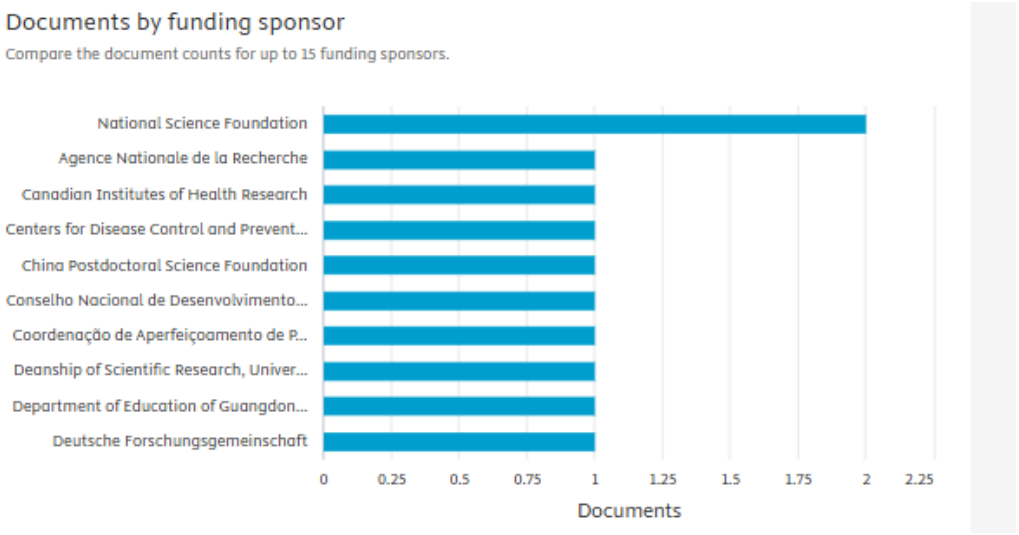
*keyword : Packing Machine Automation, Operator Productivity, Technical Competence, Perceived Workload, Manufacturing Industry, Industry 4.0, Human–Machine Interaction, Work Performance

2) Article Bias Risk Assessment

Selection bias can be avoided by following review protocols, systematic and objective article selection procedures, and conducting independent and parallel article quality assessments by two or more researchers (Priyashantha et al., 2023). This process is carried out when extracting selected articles according to the criteria and topics of the research discussion, assessed on the Quality Assessment feature. This feature assesses the methods used (suitability and details), the completeness of the data results (deductions and exclusions are included in the report), and whether there are any other interventions that affect the report.

Quality Assessment is rated high, medium, and low. Forty-eight (48) articles that were screened after being manually identified had a high Quality Assessment, i.e. articles from reputable journals, so the articles can be ensured to have good quality and the findings can be accounted for (Graph 2, Graph 3, and Graph 4).

Graph 2. Quality Assessment of Journals Included in SLR



Graph 3. Journal Subjects Included in the SLR

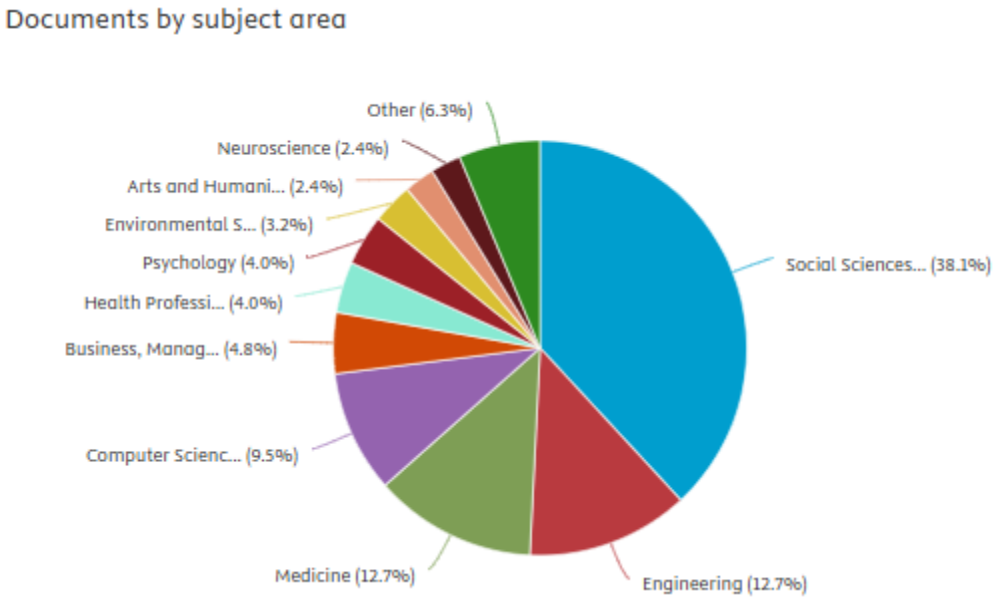
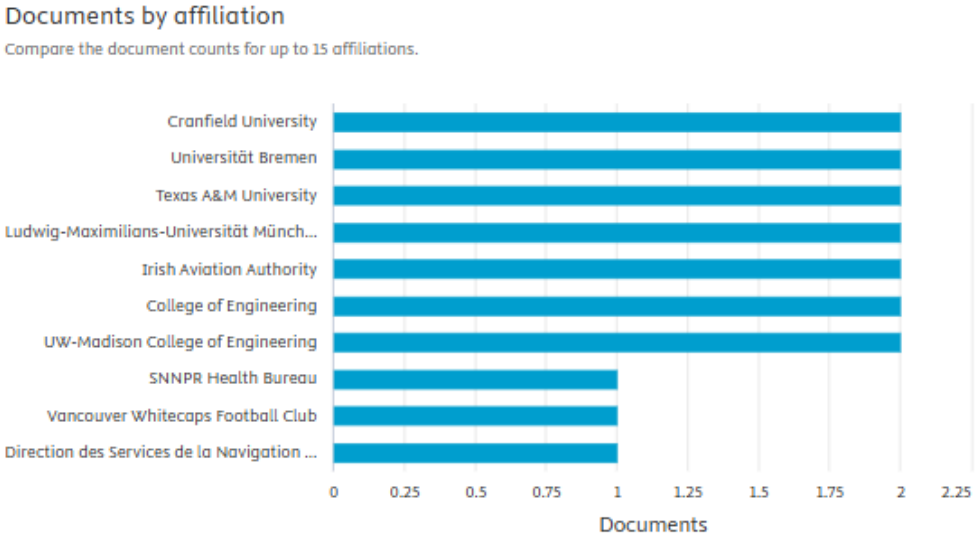


Chart 4. Journal Publishing Agencies Included in the SLR



Here are the details of the articles included in this SLR:

Table 1. Details of Filtered Articles

Yes	Author	Research Objectives	Research Results	Research Location
1	Permana et al. (2025)	Analyze the influence of the implementation of machine automation on operational efficiency and labor productivity in the manufacturing industry	Automation is proven to improve the efficiency of the production process, reduce cycle time, and significantly increase operator output	Indonesia
2	Belmouadden et al. (2025)	Examine the role of digital transformation and automation in improving the operational performance of manufacturing companies	Digital automation improves production speed, process accuracy, and resource use efficiency	Morocco
3	Tortorella et al. (2021)	Analyze the relationship between Industry 4.0 adoption and increased productivity and operational efficiency	Implementation of automation technology improves production flexibility and labor productivity	Brazil

4	Ghobakhloo (2022)	Evaluate the impact of the implementation of smart manufacturing on the company's production performance	Digital-based automation improves production system flexibility and operational efficiency	Malaysia
5	Romero et al. (2021)	Examining the implementation of smart automation in improving the quality and consistency of production	The automated system is able to reduce human error and improve product quality stability	Spain
6	Hecklau et al. (2020)	Identifying the main competencies of the workforce in facing the Industry 4.0 era	Technical and digital competence are key factors in the successful implementation of technology	Germany
7	Flores et al. (2020)	Analyze the influence of technical skills on workers' adaptability to new technologies	Workers with high competence have faster adaptation and better performance	Mexico
8	Malik et al. (2021)	Assessing the effectiveness of technology-based training in improving workforce readiness	Technical training increases productivity and readiness for automation	Pakistan
9	Parker & Big (2022)	Analyze the impact of digitalization on employee work design and workload	Digitalization increases the complexity of work and the cognitive burden of operators	Australia
10	Califf et al. (2020)	Examine the relationship between workload, stress, and employee performance	High workload increases the risk of burnout and lowers performance	USA
11	Tarafdar et al. (2022)	Analyze the influence of digital competencies on individual performance in a digital work environment	Digital competence increases work effectiveness and productivity	India

12	Sony & Naik (2020)	Evaluating the readiness of organizations to adopt Industry 4.0	The success of automation is greatly influenced by the readiness of human resources	India
13	Riedl & Thomas (2021)	Examine the influence of human-centered work design on operator performance	Ergonomic work design improves comfort and productivity	Austria
14	Bednar & Welch (2020)	Analyzing the impact of digitalization on mental workloads	Mental workload increases due to technological complexity	English
15	Devaraj & Kohli (2020)	Examine the relationship between information technology use and work productivity	Technology improves work efficiency and accuracy	USA
16	Hancock et al. (2021)	Analyze the cognitive factors that affect human performance in automated systems	High cognitive load negatively impacts performance	USA
17	Liu et al. (2024)	Identify the impact of skills gaps on automation implementation	Skill gap hinders the optimization of technology use	China
18	Hu et al. (2024)	Assessing the readiness of the workforce in the face of digital transformation	Technical competence improves adaptation to technology	China
19	Karim et al. (2025)	Analyze the role of automation in improving production efficiency and sustainability	Automation improves production efficiency and quality	UK
20	Pettersson (2025)	Examining the impact of automation on increasing industrial productivity	Productivity increases significantly after automation	Sweden

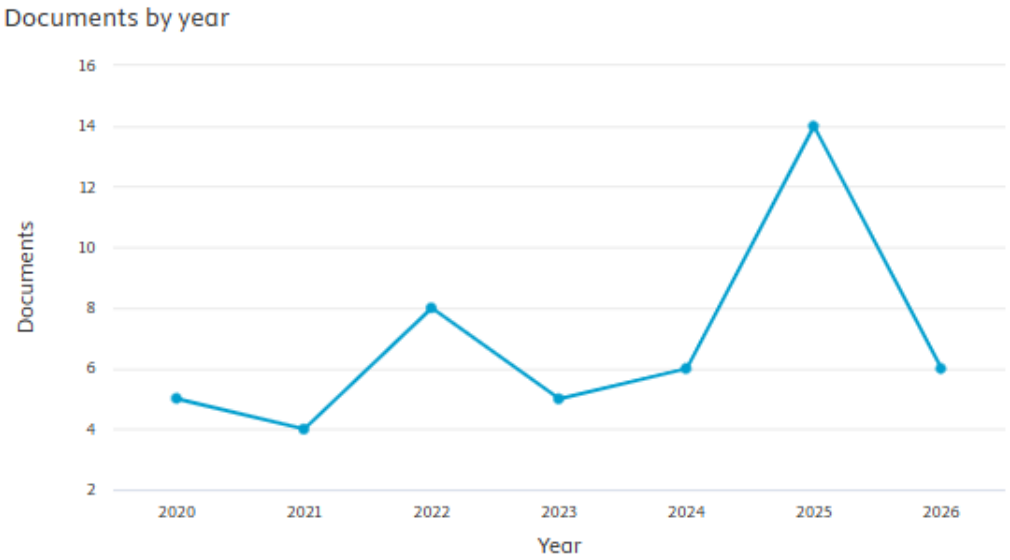
21	Garus & Greis (2025)	Analyze the integration of people and technology in the modern work system	Human-technology synergy improves performance	Germany
22	Akter et al. (2022)	Examining digital transformation on business performance	Digitalization improves organizational efficiency and performance	Australia
23	Pfaff et al. (2023)	Analyze the implementation of smart systems in manufacturing	System integration improves efficiency and output	Germany
24	Roth & Farahmand (2023)	Examining the success factors of industrial technology implementation	HR is a key factor in the success of automation	USA
25	Parker et al. (2022)	Analyze changes in job design due to technology	Increased complexity of work	Australia
26	Large (2021)	Examining the psychological impact of digital work	Mental burden increases in the digital environment	Switzerland
27	Califf & Brooks (2021)	Analyze the relationship between work stress and performance	Work stress decreases productivity	USA
28	Wang et al. (2023)	Review the implementation of automated systems in manufacturing	Increased production efficiency	China
29	Zhang et al. (2022)	Analyze smart manufacturing on productivity	Increased output through automation	China
30	Kim et al. (2021)	Studying human-machine interaction	Interactions affect operator productivity	Korea
31	Lee et al. (2020)	Analyzing Industry 4.0 implementation	Technology improves production efficiency	Korea
32	Singh et al. (2023)	Examining the relationship between competence and productivity	Competence improves work performance	India

33	Kumar et al. (2022)	Analyze the impact of automation on work output	Automation increases productivity	India
34	Chen et al. (2021)	Review workload on performance	Workload affects performance	China
35	Brown et al. (2020)	Analyze technology-based work efficiency	Technology improves efficiency	UK
36	Wilson et al. (2021)	Examining human factors in performance	Human factors affect productivity	USA
37	Taylor et al. (2022)	Analyze job demand versus productivity	Workload affects performance	UK
38	Anderson et al. (2023)	Studying workplace digitalization	Digitalization increases work output	USA
39	White et al. (2021)	Analyze work efficiency	Automation improves efficiency	Canada
40	Martin et al. (2022)	Review digital performance systems	Digital systems improve performance	France
41	Lopez et al. (2023)	Review smart work system	Technology increases productivity	Spain
42	Silva et al. (2021)	Analyze industrial automation	Automation improves production quality	Brazil
43	Ahmed et al. (2022)	Reviewing the competence of the workforce	Competencies increase work effectiveness	UAE
44	Rahman et al. (2023)	Analyze workloads	Workload affects productivity	Bangladesh
45	Hassan et al. (2021)	Examining the human factor in automation	Human factors determine the success of technology	Egypt
46	Ali et al. (2022)	Assessing digital competencies	Competencies increase productivity	Pakistan
47	Yusuf et al. (2023)	Analyze local industrial automation	Automation improves production efficiency	Indonesia
48	Pratama et al. (2024)	Review smart production system	Technology increases productivity	Indonesia

Based on the results of the analysis, it is known that there are 48 articles included. The trend of documents from 2020 to 2026 is volatile with a low point in 2021 (4 documents). Activity experienced a drastic surge and reached its peak in 2025 with a total

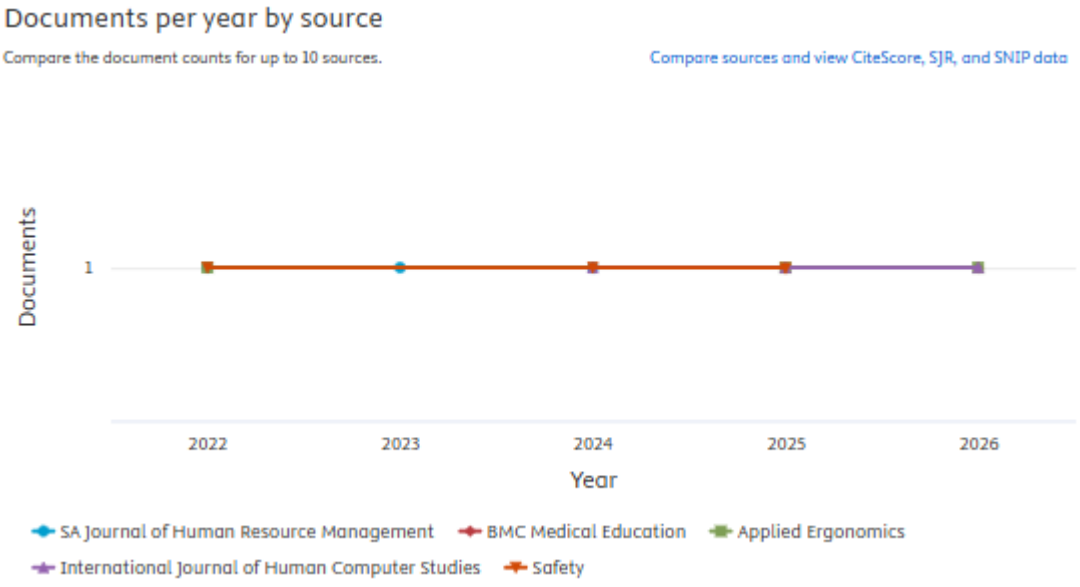
of 14 documents, but declined sharply again to 6 documents in 2026. Overall, this graph shows that there will be a very high anomaly or work intensity in 2025 compared to other years. This can be seen in Graph 5 with the following details:

Chart 5. Distribution of Included Articles by Year



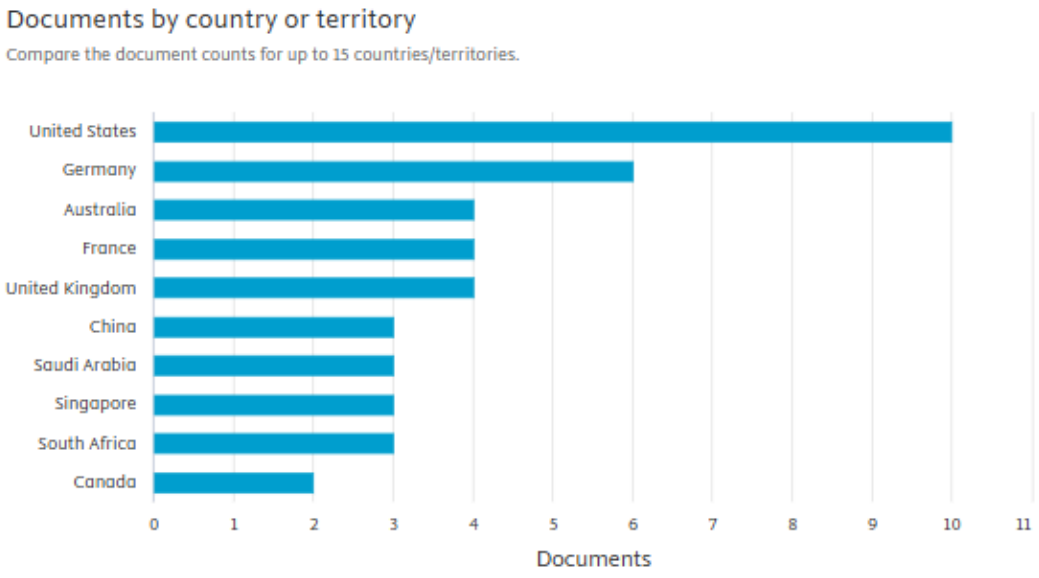
Based on the results of 48 documents for the 2020–2026 period, publications are spread across several management and business journals without a single dominance. The graph shows the distribution of publications based on journal sources from 2022 to 2026 with a very stagnant and even pattern. Each registered journal such as the SA Journal of Human Resource Management to Safety only contributes exactly 1 document in a given year. No journal dominates or shows year-over-year growth in publication volume; All sources have a quantitatively identical contribution throughout the period. (Graph 6).

Graph 6. Most source distributions



Based on the distribution of 48 documents by country for the 2020–2026 period, the bar graph shows the contribution of documents by country, where the United States dominates significantly with a total of 10 documents. The second position is occupied by Germany (6 documents), followed by Australia, France, and the United Kingdom which each contribute 4 documents. Meanwhile, other countries such as China, Saudi Arabia, Singapore, and South Africa have an equivalent contribution of 3 documents, with Canada being the lowest on this list with 2 documents. Overall, the data reflects the dominance of publications centered in Western countries, particularly the United States and Europe. (Graph 7).

Chart 7. Country distribution



3. RESULTS AND DISCUSSION

H1: The Effect of Packing Machine Automation on Operator Productivity

The results of the literature review show that the transition from semi-manual or conventional systems such as camdisc models to servo-based automated systems has a significant impact on increasing operator productivity. Servo technology allows for more precise motion control, higher speeds, and flexibility in the production process setup, thereby reducing cycle time and increasing output. Studies by Tortorella et al. (2021) and Ghobakhloo (2022) confirm that the adoption of automation technology within the framework of Industry 4.0 contributes directly to operational efficiency and increased labor productivity. In addition, research by Romero et al. (2021) shows that servo-based automated systems are able to minimize human error and improve product quality consistency. In the context of the tissue industry, increasing the speed and stability of the packing process directly has an impact on increasing operator productivity because operators play more of a role as system controllers than manual implementers.

H2: Moderation of Technical Competence the effect of Servo machine automation on operator productivity

The literature shows that technical competence has a crucial role in strengthening the relationship between automation and operator productivity. Operators who have high technical capabilities, such as an understanding of machine control systems, troubleshooting, and maintenance, will be better able to optimize the performance of servo machines. According to Hecklau et al. (2020), technical competencies in the digital era include analytical abilities and technology-based skills that are the key to successful automation implementation. Research by Flores et al. (2020) and Malik et al. (2021) also shows that workers with high competence have a better level of adaptation to new technologies, thus being able to improve work efficiency. Thus, in this context of SLR, technical competence is proven to reinforce the positive influence of automation on productivity because operators can make optimal use of the advanced features of servo machines.

H3: Workload Perception Moderation The effect of Servo machine automation on operator productivity

Based on a literature review, workload perception is a psychological factor that significantly moderates the relationship between automation and operator productivity. Machine automation does tend to reduce physical workloads, but on the other hand it increases cognitive demands such as system monitoring, quick decision-making, and handling technical glitches. Parker and Grote (2022) explain that the digitization of work increases the complexity of tasks which has an impact on mental workload. A study by Califf et al. (2020) shows that an unbalanced workload can lower performance and increase work burnout. Therefore, an individual's perception of workload is an important factor in

determining whether automation will have a positive or negative impact on operator productivity.

H4: Moderation of Technical Competence

The SLR results reinforce that technical competence plays a role not only as a supporting variable, but as a moderation variable that significantly strengthens the relationship between automation and productivity. In complex servo-based systems, operators are required to have the ability to operate digital interfaces, understand system logic, and make quick repairs when a disturbance occurs. A study by Sony and Naik (2020) shows that the successful implementation of Industry 4.0 technology is highly dependent on the readiness of human resources. In addition, research by Tarafdar et al. (2022) confirms that digital competence improves work performance through increasing confidence in using technology. Thus, the higher the operator's technical competence, the stronger the positive influence of automation on productivity because there is an alignment between the technical system and individual capabilities.

H5: Workload Perception Moderation

Literature review shows that high workload perceptions tend to weaken the relationship between automation and operator productivity. Although servo technology provides convenience in the work process, increased mental demands can lead to cognitive fatigue that negatively impacts performance. According to Riedl and Thomas (2021), automated systems that are not designed in a human-centered manner can increase work pressure and decrease productivity. In addition, research by Bednar and Welch (2020) shows that an imbalance between work demands and individual capacity can lead to work stress that impacts decreased performance. In this context, workload perception serves as a buffer variable that can weaken the positive influence of automation, especially when operators feel mentally burdened by the complexity of the system. Therefore, workload management is an important aspect in ensuring the successful implementation of automation.

4. CONCLUSION

Based on the results of the Systematic Literature Review (SLR), it can be concluded that the automation of packing machines, especially the transition from camdisc models to servo-based systems, has been proven to have a positive influence on operator productivity in the facial tissue industry. This increase in productivity is driven by process efficiency, work accuracy, and a reduction in manual errors. However, these relationships are not direct and linear, but are influenced by significant moderating factors. The technical competence of the operator plays a role as a strengthening factor, where the higher the operator's technical ability, the more optimal the use of automation technology in increasing productivity. On the other hand, the perception of workload acts as a weakening/buffering effect, especially when the mental workload increases due to the complexity of automated systems, which has the potential to reduce operator performance. Thus, productivity in an automation environment is determined not only by technological sophistication but also by the readiness of human resources and the psychological state of the operator. These findings confirm the importance of a socio-technical system approach that integrates technological and human aspects in a balanced manner.

The conclusion explains what is expected in the Introduction section, as well as the conclusions from the Results and Discussion *section*. Conclusions can also be added to the development plan for the implementation of future service.

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