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Integrating RPA, BPM, and DT in the context of Industry 4.0 and 5.0: a strategic approach for modern enterprises

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ABSTRACT

This paper examines the interaction between robotic process automation (RPA), business process management (BPM), and digital transformation (DT)-three critical components in improving operational efficiency and driving business modernization. RPA automates repetitive tasks, reduces errors, accelerates processing, and optimizes resource use. When combined with artificial intelligence (AI) and machine learning (ML), it further enhances data analysis and decision-making. BPM focuses on analyzing, designing, and optimizing business processes to ensure organizational agility. DT provides a technological foundation for broader innovation in processes and structures. The paper contributes a comprehensive and updated perspective on how RPA, BPM, and DT interrelate—not only functioning independently but also reinforcing one another to create greater business value. It emphasizes that their integration is a strategic approach to improving performance, responsiveness, and continuous innovation. Importantly, the research is relevant to both Industry 4.0 and Industry 5.0. While Industry 4.0 (I4.0) prioritizes automation and data-driven systems, Industry 5.0 (I5.0) highlights human–technology collaboration for more adaptive and human-centric organizations. This study enriches theoretical insights and offers practical guidance for building effective and sustainable DT strategies.

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1. INTRODUCTION

In the context of Industry 4.0 (I4.0) and 5.0 (I5.0), businesses face the challenge of integrating process automation with robots (RPA), business process management (BPM), and digital transformation (DT) to enhance operational efficiency, organizational flexibility, and sustainable innovation, while also reducing human errors and optimizing resources. However, the interaction between these elements often leads to complexity in implementation, especially in transitioning economies like Vietnam, where a comprehensive strategic framework is lacking.

Related studies on robotic process automation (RPA), BPM, and DT have explored this integration from various perspectives and individual aspects. Malik and Pasha [1] analyzed the role of data management (DM) and automation level (AL) in the textile industry of Pakistan, finding that DM and AL promote the adoption of I4.0 but have a negative relationship with supply chain (SC) performance due to resource constraints. Laužikas *et al.* [2] proposed effectiveness and performance criteria for applying mechatronics in business processes, highlighting differences between high-tech and low-tech businesses, with findings that business models and innovation culture determine success. Popoola *et al.* [3] developed a cross-industry business process redesign (BPR) framework, combining conceptual models like CMMI and practical execution to optimize processes through artificial intelligence (AI) and RPA, demonstrating improvements in industries like manufacturing, healthcare, and finance. Tariq *et al.* [4] identified drivers (such as advancements in deep learning and cloud computing) and barriers (culture, lack of skills) to operational excellence through AI, emphasizing cost reduction and increased productivity. Moreira *et al.* [5] conducted a systematic literature review (SLR) on business process automation (BPA) in SMEs, identifying technologies like RPA, C-RPA, and blockchain, with findings that organizational and social factors significantly impact success. Mohsen *et al.* [6] explored the integration of AI (machine learning (ML), automation, predictive analytics, and chatbots) in finance, showing reduced human interaction and improved customer experience, but highlighting the need for strategic planning. Pintado *et al.* [7] proposed a classification of acceptance and usage factors for human-computer interface (HCI) technologies in digital services, emphasizing the role of DT in enhancing user experience across economic activities. Gomes *et al.* [8] built a core entity for organizational transformation, modeling components such as processes and technologies to support DT. Enholm *et al.* [9] conducted an SLR on AI and business value, identifying enablers/inhibitors, AI typologies, and first/second-order impacts, with findings that AI drives growth but requires overcoming organizational barriers. Aryatama *et al.* [10] emphasized strategic management for successful DT in traditional industries, finding that integrated planning reduces risks and enhances competitive advantage. Mirbabaie *et al.* [11] critically reviewed AI in medical diagnosis, classifying studies, and future directions, showing that AI improves accuracy but needs to address ethical issues and integration. Techatassanasoontorn *et al.* [12] explored metaphorical sensemaking of RPA as an emerging technology, discovering that metaphors (e.g., human, robot, and tool) shape employee perception and application.

While these studies provide a solid foundation for automation and DT, there remains a gap: the lack of a comprehensive integrated framework for RPA, BPM, and DT within I4.0/I5.0, particularly regarding how these elements interact to drive comprehensive organizational transformation, minimize cultural/skill barriers, create sustainable business value, and apply practices in developing economies as well as traditional/healthcare industries.

The following research will: systematize the interaction between RPA, BPM, and DT, clarifying how they complement each other to enhance effectiveness, automation, and business innovation; identify the role of each technology in modernization, supporting businesses in efficient application; propose an integrated model of RPA, BPM, and DT to increase adaptability and market responsiveness; point out research gaps and suggest future directions for exploring technology interactions; and provide practical foundations for building sustainable DT strategies that create long-term competitive advantages.

The following sections include: section 2 details the methodology, including research questions, data sources, and theoretical foundations; section 3 presents the main findings on the RPA-BPM-DT interaction; section 4 discusses these findings in comparison with previous literature; and section 5 discusses practical implications and future research directions.

2. RESEARCH METHOD

2.1. Research objectives and questions

Given the fragmented and rapidly evolving nature of research at the intersection of automation and DT, a SLR offers a rigorous and structured approach to map existing knowledge and identify research gaps [13]. This study conducts a SLR to examine the intersections among RPA, BPM, and DT. By synthesizing existing literature, the research aims to understand their interdependencies comprehensively. The study addresses the following key questions:

- RQ1: how does RPA interact with BPM, and what are the implications for organizational efficiency?
- RQ2: what role does RPA play in driving or supporting DT initiatives?
- RQ3: how do BPM and DT influence each other in the context of technological integration?

2.2. Data collection and searching strategy

The SLR method ensures a rigorous, transparent, and reproducible approach to identifying, evaluating, and interpreting relevant academic works. According to Kitchenham's [13], framework, the evaluation process is structured into three phases: planning, execution, and reporting. Table 1 illustrates the criteria applied to Google Scholar. While using only Google Scholar may overlook some studies, its broad scope and accessibility are prioritized to ensure feasibility and effectiveness in this research context. Google Scholar's database offers extensive coverage, open access, and high update frequency. This facilitates easy access and the ability to search for sources (journals, conferences, and other academic materials), providing a diverse and comprehensive set of studies on RPA, BPM, and DT for this research.

Table 1. Searching criteria

Element	Research details
Source	Google Scholar
Search string	AB ("RPA" and "BPM" and "DT") and AB ("SLR")
Search strategy	Scholarly journal papers or conference proceedings in English, with full-text available and without time-range restrictions.
Result	107

2.3. Selection of studies

The next step in the SLR process is selecting studies based on inclusion and exclusion criteria. According to Kitchenham's [13], framework, the research adds a quality assessment section to the study selection process to enhance the rigor and transparency of the SLR method. This addition follows the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines [14], focusing on concise criteria to evaluate the quality of the selected studies. This supports the objectivity, reliability, and repeatability of the selection process. The quality assessment criteria based on PRISMA include: i) relevance with a weight of 0-3 points: evaluates how well the study aligns with the research questions (e.g., directly discusses the interaction between RPA, BPM, and DT); ii) citation count with a weight of 0-3 points: uses data from Google Scholar, prioritizing studies with ≥50 citations to ensure academic impact; iii) peer-review status with a weight of 0-3 points: includes only articles from peer-reviewed journals or conferences, excluding books, theses, or non-official documents; and iv) methodological rigor with a weight of 0-1 point: assesses the clarity of the research methodology (e.g., does it include experimental data, or quantitative/qualitative analysis?).

The selection results are as follows: after an initial screening based on inclusion/exclusion criteria (such as language, document type, and relevance to research objectives), the quality criteria were applied to evaluate the remaining 64 articles before full reading. Each article was scored from 0-10 (based on a simple scale: 0-3 for each criterion, with a threshold of ≥7 for inclusion). After screening the abstract/intro, 31 articles met the quality threshold (≥7 points) and were read in full for analysis. Figure 1 details the research selection process through the PRISMA stages: identification, screening, eligibility, and inclusion.

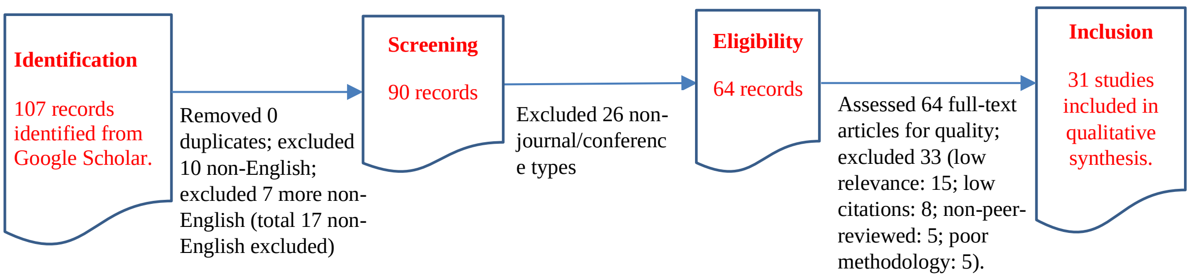

Figure 1. Filtering process of results after searching

2.4. Applying theoretical research perspectives

This paper explores the interactions between RPA, BPM, and DT. By applying interaction theories, we can better understand how RPA, BPM, and DT influence and shape one another. Drawing from key perspectives of these theories, the paper will argue, interpret, and present findings highlighting the following interactions: the relationship between RPA and BPM, the relationship between RPA and DT, and the relationship between BPM and DT. Below, we outline several theoretical perspectives used to examine the interactions between RPA, BPM, and DT:

- Theoretical perspective of information systems: information systems are a set of hardware, software, databases, telecommunications networks, people, and procedures to collect, process, store, and transmit information for an organization. Information systems support decision-making, situation analysis, planning, coordination, and control of activities, and improve the efficiency and accuracy of the organization's business operations. New technologies always create opportunities for the organization's strategy, and the organization's strategy determines the requirements for information technology infrastructure and systems. Implementing information systems with new digital technology platforms is a process of change that significantly impacts the organization, requiring adjustments to work processes and information systems to optimize the interaction between system components [13], [15].

- Theoretical perspective of technological innovation: the highlight of technological innovation is the application of new technological solutions to solve arising problems, gradually meeting human needs through new scientific and technological advances. Applying new technological solutions involves creating/upgrading the organization's products, services, or processes. Digital technology innovation to increase efficiency, reduce costs, improve quality, or bring competitive advantages to the organization. Organizations need to have measures to manage change and promote the acceptance of digital technology, helping stakeholders adapt to new technology [16]–[18].
- Cognitive theory perspective on technology: Davis's [19] technology acceptance model is the most widely applied model of user acceptance and use of technology. Venkatesh [20] further extends this by integrating determinants of perceived ease of use. Godin [21] provides historical context on the evolution of technological innovation concepts, emphasizing their inclusive development. Users' perceptions of the use and usefulness of digital technology will influence their acceptance and adoption of the technology. Acceptance of digital technology may depend on how it is integrated with existing tools and processes and the level of training support the organization provides.
- Network economic theory perspective: Håkansson and Snehota [22] has developed a comprehensive framework for analyzing business networks, underscoring the critical role of relationships, interdependence, and continuous organizational interactions. Birke [23] surveys the empirical literature on the economics of networks, highlighting how network effects drive interactions and interdependencies between different components. In an organizational context, these components are viewed as resources. These resources must be connected and integrated effectively to transform them into economic value. The introduction of innovative resources enhances organizational performance [19]. Therefore, combining digital technologies with other organizational resources within a unified network can foster interactions and create added value, such as process optimization, cost reduction, and identifying new opportunities.
- Theoretical perspective of organization and change management: people are always at the center. People are the change and will only change if they see and feel the need to do so. The leader's vision, thinking, ability, skills, and commitment will be important in promoting organizational innovation and change. Change is a continuous process that must be established systematically and sequentially. Change always has an impact on employees and the culture of the organization. The change will change the organizational culture by changing how employees work and requiring them to adjust their work habits, leading to employee resistance. Change management manages resistance by communicating the need for change and making employees feel like part of the change [24], [25]. Therefore, implementing digital technology in a DT requires a clear change management strategy to ensure the transition goes smoothly. This includes establishing a change plan, managing resistance, and maintaining leadership commitment. Digital technology can change organizational culture, creating resistance from employees. This process needs to be tightly managed to maintain employee motivation and satisfaction.
- Socio-technical systems theory perspective: coordinated and integrated human and technical activities are possible when one system supports the other. Since all subsystems are interdependent, changes in one area will influence and impact other systems. The social system aims to design a work structure that meets people's psychological needs (feelings, responsibilities, and expectations). It is reflected through the organization's culture, norms, roles, communication patterns, and social relationships. Meanwhile, the technical system includes the tools, equipment, and methods used to convert raw materials into products or services [26]–[28]. In DT, digital technologies are the driving force that creates an organization's competitive advantage. They also have many impacts that affect other resources of the organization. The interaction between technical and social factors must be considered, including adjusting workflows and training employees to maximize the benefits of digital technologies. Therefore, implementing these digital technologies must be designed to match the needs and behaviors of people in the organization. This includes ensuring that technology optimizes processes, supports and improves the user experience, and enhances the organization's operational efficiency.

2.5. Research design

This study uses 11 steps that are specifically described through the research design (Figure 2). These steps ensure that the research design process is carried out systematically, from problem identification, data collection, and processing to analysis and discussion of research results, conclusions, and model completion. This helps ensure that the research results are accurate, relevant, and highly valuable. The steps in the research design process are shown as follows: the first step is defining and establishing the research problem. In this step, it is necessary to understand RPA, BPM, and DT clearly. The next step is to establish research questions to overview the interaction between RPA, BPM, and DT. The next step is to select and search for the necessary data to analyze to answer the research questions. The next step is to apply appropriate research theories (information systems theory, technological innovation theory, cognitive technology theory, network economics theory, organization, and change management theory) to conduct analysis and present research results. The research results include (the interaction between RPA and BPM, the interaction between RPA and DT, and the interaction between BPM and DT), which have answered the research questions. The next step will discuss the research results, compare the results with other related studies, and mention the research limitations. Finally, the research conclusions are presented to complete the overall research.

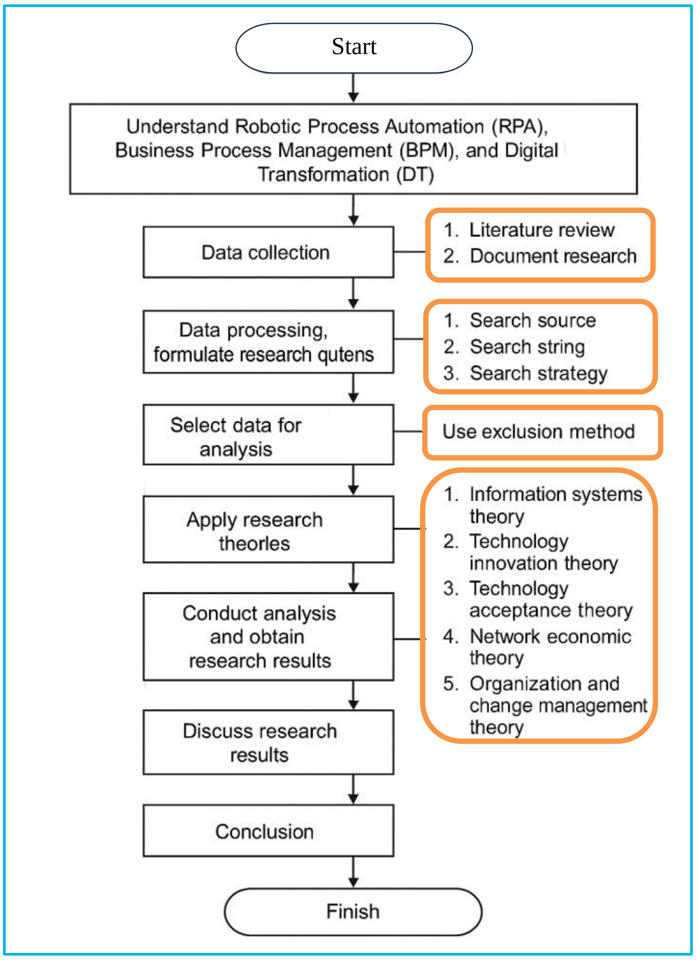

Figure 2. Research design

3. RESEARCH RESULTS

The following is how we interpret RPA, BPM, and DT in this study: RPA is a technology that automates rule-based and repetitive processes previously completed by humans using software robots. RPA can be utilized independently or with additional tools like AI to improve process automation. The BPM methodology includes analyzing, designing, implementing, monitoring, and optimizing business processes. While DT is the integration of digital technology into every aspect of the business, radically altering how companies function and provide value to their clients, BPM concentrates on streamlining the entire process to attain greater efficiency and quality. DT aims to drive innovation, enhance performance, and develop new business models. The study's findings demonstrate that BPM, RPA, and DT interact pairwise, as illustrated in Figure 3. In the following sections, precise details of these interactions will be examined.

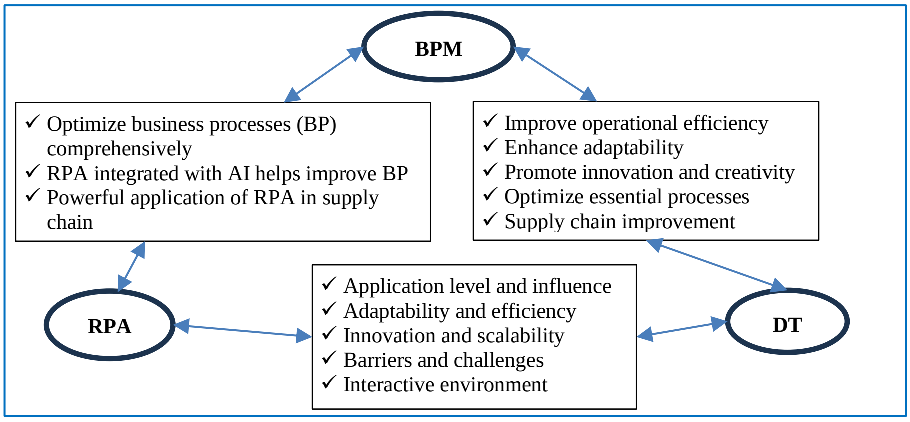

Figure 3. Interaction between RPA, BPM, and DT

3.1. The interaction between robotic process automation and business process management

RPA and BPM complement each other, providing significant benefits in managing and improving business processes (Figure 4). BPM analyzes, designs, and optimizes processes, while RPA automates repetitive, rule-based tasks such as invoice processing or customer DM [1], [5]. This combination optimizes processes comprehensively, from design to automation, enhancing efficiency, reducing errors, and speeding up execution [29], [30]. However, RPA is less flexible than BPM, focusing only on specific tasks and requiring reprogramming when processes change. In contrast, BPM is flexible, supporting process redesign to adapt to changes in the business environment [5].

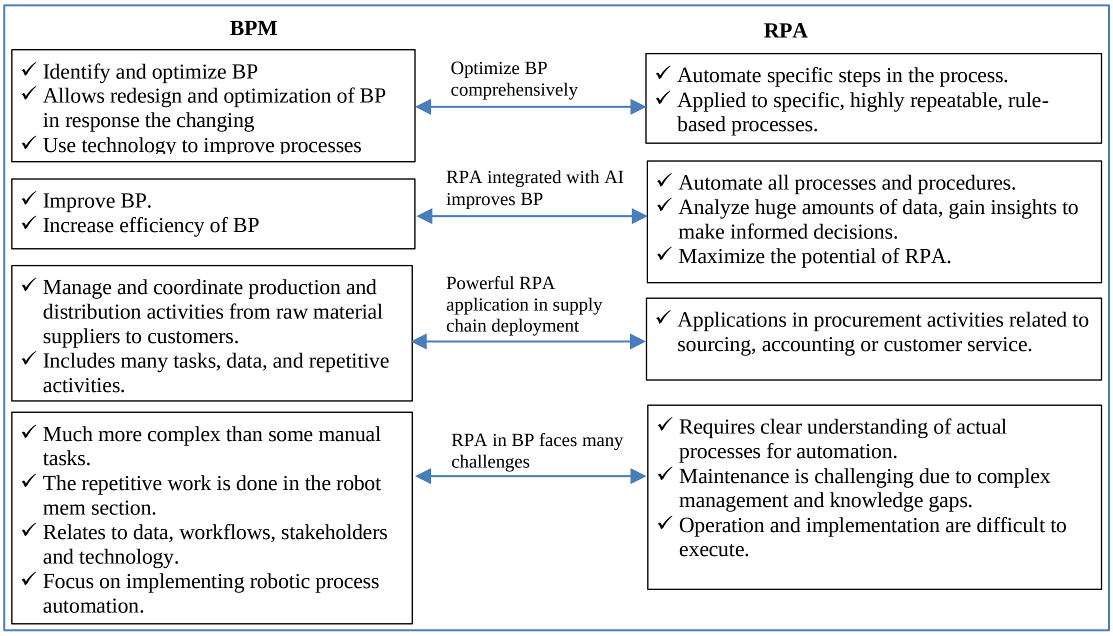

Figure 4. Interaction between BPM and RPA

Figure 4 clearly shows the interaction between RPA and BPM as follows:

- Enhancing process efficiency: integrating RPA and BPM improves performance and reduces operational costs through automation and process optimization [30], [31]. BPM identifies weaknesses, while RPA ensures steps are executed automatically and efficiently.
- Integrating AI with RPA: the combination of AI with RPA enhances automation, big data analysis, and supports intelligent decision-making [6], [32]. This integration provides a competitive advantage, reduces risks, and optimizes processes [12], [33].

- Application in SC: RPA automates repetitive tasks in the SC, such as procurement, accounting, and customer service, which have been highly rated in studies [1], [34], [35].
- Challenges in RPA implementation: implementing RPA faces challenges such as complex processes, difficulty in maintenance, and lack of knowledge about RPA [36], [37]. Around 30-50% of RPA projects fail due to process misunderstanding or poor management [30]. Additionally, a major barrier is employee resistance to digital technologies, such as fear of job loss [38]. Understanding processes and managing change effectively are key factors for successful automation and avoiding negative impacts on business operations.

3.2. Interaction between robotic process automation and digital transformation

RPA and DT have a close, complementary relationship in modernizing and optimizing business operations (Figure 5).

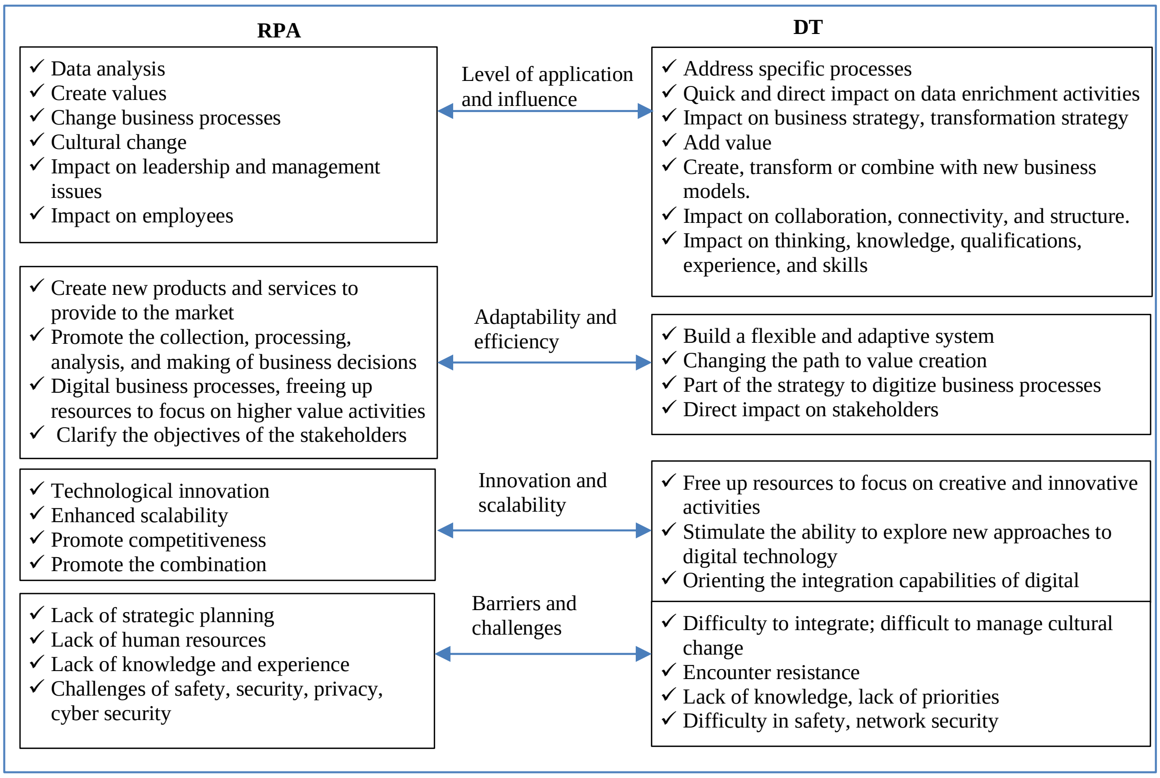

Figure 5. Interaction between RPA and DT

RPA is an essential digital technology that drives, supports, and strongly impacts DT initiatives. The key aspects of this relationship are outlined below:

- Application and impact level: RPA is often deployed to automate specific processes such as data creation, accumulation, processing, invoice management, or customer service (Table 1). Data from RPA and other digital technologies serve as inputs for analytical activities, helping businesses extract insights from large volumes of data to make informed decisions [6], [11], [32]. Advanced analytics techniques such as predictive analytics, ML, and AI support the identification of trends, patterns, and relationships within the data, optimizing business processes [1], [10], [31], [39]–[44]. RPA drives automation and influences business strategy, transformation strategy, and organizational structure. In terms of business strategy, RPA improves products, processes, and services, reduces errors, increases productivity, and enhances stakeholder satisfaction, helping free up human resources for higher-value tasks [3], [9], [10], [32], [40]. RPA and other digital technologies add value by increasing revenue, reducing costs, improving efficiency, and contributing to overall business value [1], [6], [10], [30], [40]. They help businesses make data-driven decisions, understand strategic direction in the context of changing competition, enhance competitive advantage, and improve management effectiveness [8], [10], [32]. Regarding transformation strategy, RPA drives or integrates with new business models, improves productivity, and reduces costs

[1], [5], [10], [40], [45]. Digital technologies, including RPA, change business processes, automate critical processes, and improve process models to achieve sustainable competitive advantage [5], [6], [10], [30], [39], [40]. Process analysis helps identify inefficiencies and improvement opportunities, thus enhancing decision-making effectiveness [1], [10]. Digital technologies improve business functions with robots and automated systems, changing the internal value chain and linking organizations, accumulating real-time customer data to develop new products, predict marketing, and understand customer needs [1], [10], [39]. RPA reduces dependence on human labor, increases efficiency, and leads to changes in organizational structure, labor structure, job restructuring, and the creation of new tasks [1], [10], [30], [39], [40]. Digital technologies promote internal and external collaboration, requiring a change in corporate culture to be flexible and adaptable [5], [10], [40]. Leadership must possess the mindset, knowledge, and digital skills to cope with disruptions from technology [6], [10], [40]. These changes impact job characteristics, skills, health, and employee emotions, requiring businesses to have training and development plans in the context of DT [10], [30], [32], [38], [40].

Table 1. Interaction between RPA and DT: application levels and impact

Application level and influence	Source
Data analysis	(Popoola *et al.* [3]), (Mohsen *et al.* [6]), (Laužikas *et al.* [2]), (Gandia *et al.* [40]), (Marbouh *et al.* [41]), (Mancini *et al.* [31]), (Tariq *et al.* [4]), (Aryatama *et al.* [10]), (Firmansyah and Arman [33]), (Belhadi *et al.* [43]), (Roopa *et al.* [35]), (Han *et al.* [44]), (Mirbabaie *et al.* [11]).
Creating values	(Popoola *et al.* [3]), (Enholm *et al.* [9]), (Mohsen *et al.* [6]), (Laužikas *et al.* [2]), (Malik and Pasha [1]), (Mancini *et al.* [31]), (Aryatama *et al.* [10]), (Techatassanasoontorn *et al.* [12]), (Brătucu *et al.* [32]), (Mirbabaie *et al.* [11]).
Changing business processes	(Moreira *et al.* [5]), (Menezes [36]), (Popoola *et al.* [3]), (Mohsen *et al.* [6]), (Baïna *et al.* [46]), (Vu *et al.* [37]), (AlMulhim [39]), (Laužikas *et al.* [2]), (Malik and Pasha [1]), (Peeters and Plomp [30]), (Mancini *et al.* [31]), (Tariq *et al.* [4]), (Gomes *et al.* [8]), (Brătucu *et al.* [32]).
Change organizational structure	(AlMulhim [39]), (Laužikas *et al.* [2]), (Gandia *et al.* [40]), (Malik and Pasha [1]), (Marbouh *et al.* [41]), (Peeters and Plomp [30]), (Mancini *et al.* [31]), (Tariq *et al.* [4]), (Gomes *et al.* [8]), (Techatassanasoontorn *et al.* [12]), (Brătucu *et al.* [32]), (Roopa *et al.* [35]).
Cultural change	(Moreira *et al.* [5]), (Aryatama *et al.* [10]), (Brătucu *et al.* [32]), (Gkinko and Elbanna [38]).
Impact on leadership and management issues	(Popoola *et al.* [3]), (Mohsen *et al.* [6]), (Gandia *et al.* [40]), (Aryatama *et al.* [10]), (Brătucu *et al.* [32]).
Impact on employees	(Peeters and Plomp [30]), (Aryatama *et al.* [10]), (Techatassanasoontorn *et al.* [12]), (Brătucu *et al.* [32]), (Gkinko and Elbanna [38]).

- Adaptability and effectiveness: RPA supports creating flexible systems, helping businesses rapidly change and adapt to the digital business environment (Table 2). Digital technologies, including RPA, generate new value through improved products and services [4]–[6], [12], [32], [46]. Technology platforms such as sensors and advanced algorithms support the collection, processing, and analysis of data, leading to better business decision-making, positively impacting customers and the competitive environment [2], [4], [11], [32], [41]. RPA, as part of the digital process strategy, enables rapid results and frees up resources for high-value activities [1]–[4], [10], [47]. Digital technology improves process performance, resource efficiency, and overall business effectiveness [1]–[5], [11], [30], [32], [37], [41]. Internal and external stakeholders influence RPA implementation through strategic decisions, technical support, and change management. Understanding stakeholders' goals and effectively managing implementation challenges are key to improving process effectiveness and business performance [2], [12], [36], [41], [47], [48].

Table 2. Interaction between RPA and DT: adaptability and efficiency

Adaptability and efficiency	Source
Create new products and services to provide to the market	(Moreira *et al.* [5]), (Mohsen *et al.* [6]), (Baïna *et al.* [46]), (Tariq *et al.* [4]), (Techatassanasoontorn *et al.* [12]), (Brătucu *et al.* [32]).
Drive the collection, processing, analysis and making of business decisions	(Laužikas *et al.* [2]), (Marbouh *et al.* [41]), (Tariq *et al.* [4]), (Brătucu *et al.* [32]), (Mirbabaie *et al.* [11]).
Digitize business processes, freeing up resources to focus on higher value activities	(Popoola *et al.* [3]), (Laužikas *et al.* [2]), (Malik and Pasha [1]), (Tariq *et al.* [4]), (Aryatama *et al.* [10]), (Madhura *et al.* [47]).
Improve performance	(Moreira *et al.* [5]), (Popoola *et al.* [3]), (Vu *et al.* [37]), (Laužikas *et al.* [2]), (Malik and Pasha [1]), (Marbouh *et al.* [41]), (Peeters and Plomp [30]), (Tariq *et al.* [4]), (Brătucu *et al.* [32]), (Mirbabaie *et al.* [11]).
Clarify stakeholder goals	(Menezes [36]), (Sobczak [48]), (Laužikas *et al.* [2]), (Marbouh *et al.* [41]), (Techatassanasoontorn *et al.* [12]), (Madhura *et al.* [47]).

- Innovation and scalability: the interaction between RPA and DT drives innovation and scalability (Table 3). RPA and DT foster technological innovation by integrating solutions like AI and automation, improving business processes, and creating new products/services. This helps businesses enhance efficiency and adapt to the digital environment, with a focus on organizational creativity [2], [3], [47], [5], [6], [8], [10], [30], [32], [35], [39]. Integrating RPA into DT increases process scalability, allowing businesses to expand automation without significantly increasing costs, supporting sustainable and flexible growth [2], [8], [31], [48]. RPA and DT enhance competitive advantage by optimizing processes, reducing costs, and improving market response speed, helping businesses outperform competitors [1]–[6], [8]–[10], [30], [31], [40]. The interaction between RPA and DT encourages technology integration, connecting RPA with DT systems to create a seamless ecosystem, supporting data analytics and strategic decision-making [1], [3], [4], [6], [9]–[12], [32], [43], [44], [47]. RPA and DT promote the combination of technology, processes, and people, creating hybrid models that enhance creativity and efficiency, boosting competitiveness [1]–[6], [8], [9], [11], [12], [32], [43], [44], [47].

Table 3. Interaction between RPA and DT: innovation and scalability

Innovation and scalability	Source
Technological innovation	(Moreira *et al.* [5]), (Popoola *et al.* [3]), (Mohsen *et al.* [6]), (AlMulhim [39]), (Laužikas *et al.* [2]), (Peeters and Plomp [30]), (Aryatama *et al.* [10]), (Gomes *et al.* [8]), (Brătucu *et al.* [32]), (Madhura *et al.* [47]), (Roopa *et al.* [35]).
Enhanced scalability	(Sobczak [48]), (Laužikas *et al.* [2]), (Mancini *et al.* [31]), (Gomes *et al.* [8]).
Promote competitiveness	(Moreira *et al.* [5]), (Popoola *et al.* [3]), (Enholm *et al.* [9]), (Mohsen *et al.* [6]), (Laužikas *et al.* [2]), (Gandia *et al.* [40]), (Malik and Pasha [1]), (Peeters and Plomp [30]), (Mancini *et al.* [31]), (Tariq *et al.* [4]), (Aryatama *et al.* [10]), (Gomes *et al.* [8]).
Promote integration	(Popoola *et al.* [3]), (Enholm *et al.* [9]), (Mohsen *et al.* [6]), (Malik and Pasha [1]), (Tariq *et al.* [4]), (Aryatama *et al.* [10]), (Techatassanasoontorn *et al.* [12]), (Brătucu *et al.* [32]), (Belhadi *et al.* [43]), (Madhura *et al.* [47]), (Han *et al.* [44]), (Mirbabaie *et al.* [11]).
Promote the combination	(Moreira *et al.* [5]), (Popoola *et al.* [3]), (Enholm *et al.* [9]), (Mohsen *et al.* [6]), (Laužikas *et al.* [2]), (Malik and Pasha [1]), (Tariq *et al.* [4]), (Gomes *et al.* [8]), (Techatassanasoontorn *et al.* [12]), (Brătucu *et al.* [32]), (Belhadi *et al.* [43]), (Madhura *et al.* [47]), (Han *et al.* [44]), (Mirbabaie *et al.* [11]).

- Barriers and challenges: despite offering numerous benefits, RPA and DT face challenges related to people, safety, and security (Table 4). The lack of skilled personnel is a significant barrier, limiting the ability to effectively deploy and operate RPA solutions within DT, requiring investment in training and workforce development [10], [32], [36]. Companies often lack knowledge and experience in RPA and DT, leading to difficulties in applying and optimizing the technology, which reduces the effectiveness of implementation [5], [32], [40]. Integrating RPA into DT increases the risk of data leaks or misuse if not managed carefully. Security and privacy issues become significant challenges, especially when combined with AI, requiring robust protection measures and clear management policies to mitigate risks [1], [5], [6], [32], [33], [40], [42], [47].

Table 4. Interaction between RPA and DT: barriers and challenges

Barriers and challenges	Source
Lack of human resources	(Menezes [36]), (Aryatama *et al.* [10]), (Brătucu *et al.* [32]).
Ignorance and inexperienced	(Moreira *et al.* [5]), (Gandia *et al.* [40]), (Brătucu *et al.* [32]).
Challenges in safety, security, privacy, and cyber security	(Moreira *et al.* [5]), (Mohsen *et al.* [6]), (Gandia *et al.* [40]), (Malik and Pasha [1]), (Szpilko *et al.* [42]), (Firmansyah and Arman [33]), (Brătucu *et al.* [32], (Madhura *et al.* [47]).

- Interactive environment: RPA and digital technologies have redefined the social structure in many aspects and could change the labor structure, leading to significant changes in the economy, society, ethics, and legislation (Table 5). RPA and DT reshape the socio-economic structure, alter how business operations are organized, and influence social interactions, driving the shift towards digital business models, creating new opportunities and challenges [2], [32], [40], [42]. The application of RPA and DT causes job disruption, changes the labor structure, and demands job restructuring and digital skill training to adapt, while also requiring effective change management to reduce employee resistance [30], [32], [40], [47]. The integration of RPA and DT presents ethical challenges, especially regarding data privacy, requiring businesses to prioritize transparency and accountability to maintain stakeholder trust [6], [32], [40], [42], [47]. Governments and organizations themselves need to establish clear regulations to support safe and sustainable DT, particularly in sectors like FinTech, where regulatory compliance costs are high and the risk of information fraud increases [32], [33], [40], [47].

Table 5. Interaction between RPA and DT: interaction environment

Interactive environment	Source
Socio-economic structure	(Laužikas *et al.* [2]), (Gandia *et al.* [40]), (Szpilko *et al.* [42]), (Brătucu *et al.* [32]).
Labor structure	(Gandia *et al.* [40]), (Peeters and Plomp [30]), (Brătucu *et al.* [32]), (Madhura *et al.* [47]).
Ethical issues	(Mohsen *et al.* [6]), (Gandia *et al.* [40]), (Szpilko *et al.* [42]), (Brătucu *et al.* [32]), (Madhura *et al.* [47]).
Legal issues, legal conditions	(Gandia *et al.* [40]), (Firmansyah and Arman [33]), (Brătucu *et al.* [32]), (Madhura *et al.* [47]).

3.3. The interaction between business process management and digital transformation

BPM and DT are crucial factors in modernizing and improving business performance (Figure 6). BPM helps analyze and identify weaknesses and opportunities for improvement, while DT changes businesses' culture, processes, and technology [3], [5]. This combination improves existing processes and creates new business models [3], [4].

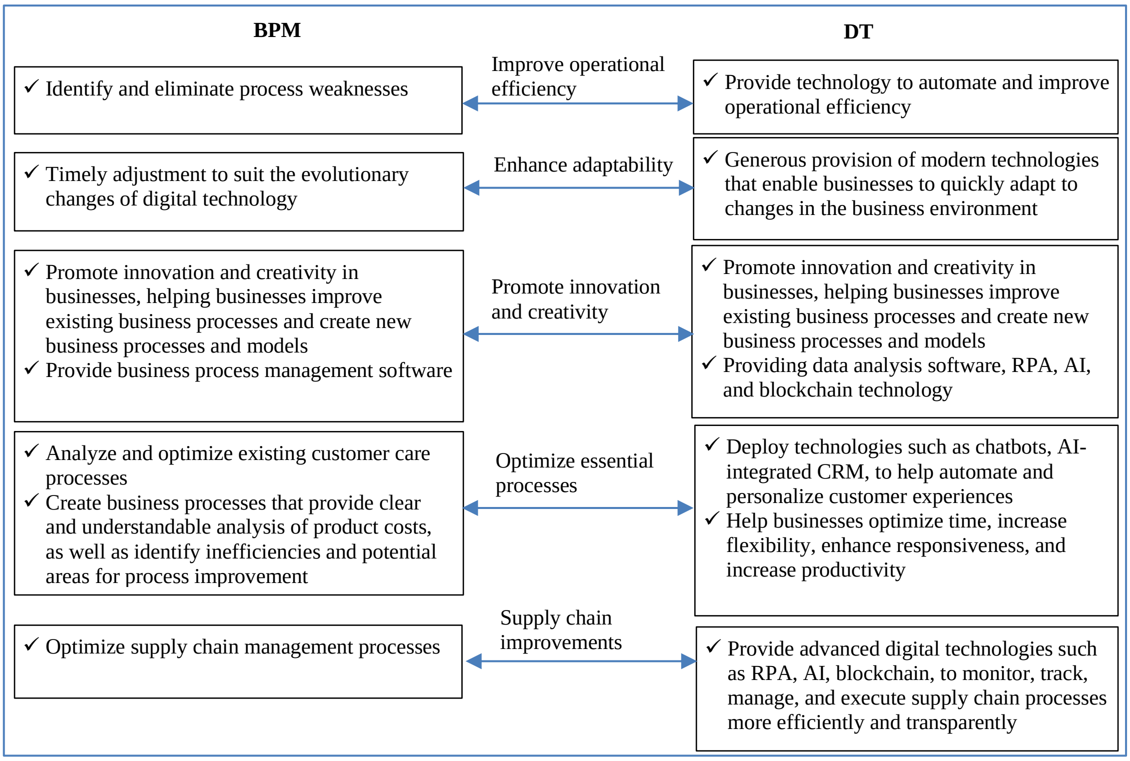

Figure 6. Interaction between BPM and DT

The interaction between BPM and DT is clearly demonstrated in the following aspects:

- Improving business performance: BPM eliminates weaknesses in processes, while DT provides technologies like RPA, AI, internet of things (IoT), and big data analytics to automate and enhance efficiency [1], [5], [39]. Particularly in the SC, BPM optimizes processes, and DT provides tools for monitoring and automation, improving performance [1], [4], [34], [39].
- Increasing adaptability: BPM adjusts processes to align with digital technology changes, while DT provides modern technologies that help businesses quickly adapt to the business environment [1]. Robots and ideas from DT predict customer needs, increasing adaptability [1], [44].
- Fostering innovation: the combination of BPM and DT drives creativity, improves existing processes, and creates new business models. The integration of BPM software, RPA, AI, and blockchain helps innovate processes and enhance efficiency [3], [31], [32], [39].

- Optimizing core processes: BPM analyzes and improves processes such as customer care, while DT deploys technologies like chatbots, and AI-integrated CRM to automate and personalize customer experiences [3], [5], [6], [41].
- Improving the SC: DT increases flexibility, responsiveness, and productivity, particularly in the SC, through technologies like RPA, AI, blockchain, and IoT [3], [4], [34], [39], [43]. BPM and DT complement each other, enhancing efficiency, adaptability, innovation, and effective SC management.

4. DISCUSSION

The research results align with established viewpoints in the literature, emphasizing the complementary relationship between RPA, BPM, and DT while revealing gaps and contradictions requiring critical scrutiny. The research directly connects its findings to the posed research questions, highlighting the following issues for discussion:

Firstly, for RQ1 (how does RPA interact with BPM, and what is its significance for organizational effectiveness?), the findings affirm that BPM provides a platform for process optimization. At the same time, RPA focuses on automating repetitive tasks, reducing errors, and increasing speed [3], [5], [30]. However, the literature [30], [37] present contradictions about RPA's flexibility: one side emphasizes the benefit of integrating AI to enhance decision-making [6], [32], while the other points to a high failure rate (30-50%) due to complex maintenance and a lack of theoretical explanation for multidimensional impacts, suggesting that organizational effectiveness may be exaggerated without long-term experimental data. This study fills the gap by emphasizing that the RPA-BPM combination improves performance and fosters adaptability. However, existing literature often overlooks cultural challenges, such as employee resistance [36], leading to imbalanced effectiveness estimates.

Secondly, for RQ2 (what role does RPA play in driving or supporting DT initiatives?), the research findings demonstrate that RPA supports DT by automating data and processes, fostering innovation, and scalability [1], [12], [34]. Literature [4], [9] are consistent about its positive impact on business value. However, contradictions appear in [30], [40], where some studies highlight quick benefits (cost reduction, increased productivity), while others point out security and privacy risks, especially when integrating AI [42]. A notable gap is the lack of quantitative analysis on the socio-labor impact, such as changes in employment structure [40]. Meanwhile, this study contributes new perspectives on social impact by linking RPA with cultural and leadership changes. It also points out that most studies in the existing literature tend to focus on the technological aspect, with little sociological critique.

Thirdly, for RQ3 (how do BPM and DT influence each other in the context of technological integration?), the findings emphasize that DT provides tools (such as AI and IoT) to enhance BPM flexibility, leading to new business models [3], [38], [42]. Literature [2], [10] support this coordination in SCs. However, contradictions emerge in [30] and [49], where some highlight innovation, while others indicate limitations in real-world integration due to a lack of implementation frameworks. The limitations of the existing literature include the lack of cross-disciplinary experimental data, with a primary focus on I4.0, and the absence of the human-centered aspect of I5.0 [11]. This study identifies this gap by proposing strategic integration. However, the study's limitation lies in the continued lack of quantitative analysis, which diminishes its persuasive power.

Thus, while the literature is consistent on the benefits, contradictions about risks and the lack of experimental critique (e.g., optimistic bias in [1], [3]) emphasize the need for future research with quantitative data and multidimensional frameworks to address gaps and ensure sustainability in DT.

Based on the new findings of the paper, which emphasize the complementary relationship between RPA, BPM, and DT but also highlight gaps such as high failure rates (30-50%) due to complex maintenance, lack of flexibility, employee resistance, and security risks, an integrated model is proposed. This model, succinctly named the "RPA-BPM-DT Phased Integration Model (RBD-Phased Model)," is suitable for synthesizing dynamic interactions (from RPA's task automation, BPM's process optimization, to DT's comprehensive innovation) into a strategic framework, aiming to reduce contradictions and fill gaps by prioritizing sustainability and human-centered automation in successful DT for organizations. RBD will be a three-layer interconnected system, with DT as the strategic foundation, BPM as the intermediary optimization layer, and RPA as the automation execution layer. The layers interact bidirectionally: RPA provides real-time data to BPM for process redesign, while DT ensures the integration of AI/IoT to enhance flexibility and reduce risks. The model's goal is to: increase organizational effectiveness (reduce errors by 20-30% according to [29]), promote innovation, and reduce failure rates through change management. The layers are: i) Layer 1: DT (innovation platform): provides digital tools (AI, IoT, and blockchain) to support comprehensively, focusing on culture and organizational structure; ii) Layer 2: BPM (process optimization): analyzes and redesigns processes for adaptability, reduces weaknesses, and integrates people; and iii) Layer

3: RPA (execution automation): automates specific tasks, integrates AI to analyze data and reduce costs. The interaction of RPA, BPM, and DT will be: RPA→BPM (automation data for optimization); BPM→DT (flexible processes supporting innovation); DT→RPA (technology enhancing scalability). To implement the model, organizations should follow a phased strategy, focusing on choosing automation tools based on scale, industry (e.g., SC, finance), and digital maturity. Each phase incorporates risk assessments (e.g., security and employee resistance) alongside KPI metrics (e.g., performance and ROI). These phases are outlined in detail in Table 6.

Table 6. Implementation stages of the RBD model

Deployment phases	Recommendations	Automation support tools	Timeline and performance metrics
Planning establishment	Identify process gaps (using BPM to analyze weaknesses), assess employee skills, and security risks. Prioritize training to reduce resistance [35]. Focus on RQ1 to understand the RPA-BPM interaction.	Basic BPM tools (e.g., Microsoft Visio, Lucidchart) for process mapping.	1-3 months; KPI: gap report (≥80% of processes identified).
Process optimization	Apply BPM to redesign processes flexibly, integrate DT to add predictive AI. Resolve flexible conflicts through pilot testing.	Advanced BPM tools (e.g., Camunda, Bizagi) combined with AI (e.g., IBM Watson for analytics).	3-6 months; KPI: reduce process time by 15-20%, error rate <10%.
Automation integration	Implement RPA for repetitive tasks (e.g., data processing), connect with DT to expand (AI for smart decision-making). Focus on RQ2 to support DT initiatives, reduce failures through regular maintenance [29].	RPA tools (e.g., UiPath, automation anywhere) integrated with AI (e.g., Google Cloud AI).	6-12 months; KPI: speed up processing by 30-50%, ROI >20%.
Expansion and upgrade	Expand organization-wide with DT at the core, integrating IoT/blockchain for the SC. Address RQ3 with cultural change management [39].	Comprehensive DT tools (e.g., AWS IoT, Azure Blockchain) with hybrid RPA/BPM.	Over 12 months; KPI: increase revenue by 10-15%, employee satisfaction survey ≥70%.
Monitoring and management	Continuous evaluation, using experimental data to adjust (fill research gaps). Handle security risks with policies [41].	Monitoring tools (e.g., Splunk for log analysis, Tableau for dashboards).	Ongoing; KPI: failure rate <20%, quarterly updates.

This model encourages businesses to start small (pilot in one department), prioritizing SMEs in developing and transitioning economies like Vietnam, and incorporating quantitative evaluation to address the limitations of existing literature. Future research could validate the model through real-world case studies.

5. CONCLUSION

This study clarifies the dynamic interactions between DT, BPM, and RPA, emphasizing their strategic integration in enhancing process efficiency and enabling broader organizational transformation. The findings demonstrate how the combination of RPA and BPM optimizes business operations and supports structural and cultural shifts required in DT initiatives. However, challenges such as high maintenance costs, employee resistance, and data security risks underscore the importance of careful planning, effective change management, and robust regulatory frameworks when implementing these technologies, particularly RPA.

Despite its contributions, this study, as a typical SLR research, has several limitations. Construct validity may be affected by definitional overlap among RPA, BPM, and DT. This was reduced by upfront, theory-based definitions and a piloted coding guide. Selection and publication bias were mitigated by the transparent integration of the Kitchenham guidelines and PRISMA flow and PRISMA flow, explicit inclusion/exclusion rules, and sensitivity checks around the ≥50-citation threshold. External validity is constrained by reliance on a single source (Google Scholar), English-only inclusion. This risk was partly offset by broad time coverage, backward/forward snowballing, and documenting missed venues for future extensions. Internal validity limits of largely observational studies were handled by avoiding causal claims and using triangulated, theory-informed narrative synthesis rather than effect-size meta-analysis. Reliability was strengthened via a standardized 0–10 quality rubric, audit trails, and cross-checks on borderline papers.

To advance this field, future research should: i) conduct empirical evaluations of RPA–BPM integration outcomes; ii) develop comprehensive implementation frameworks addressing organizational, technical, and cultural challenges; iii) explore technological synergies with AI, IoT, and ML to enhance RPA capabilities; and iv) examine the ethical, legal, and regulatory dimensions of adopting these technologies to ensure responsible and sustainable DT.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest regarding the publication of this paper.

DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon request.

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