Potential Applications of Robotic Process Automation in Supply Chain Operations

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Abstract*— Supply Chain of industries particularly manufacturing industries forms the backbone of their business operations. In this century of digital transformation, supply chain activities of companies require digitization up to a certain level to save cost and time. We see, lack of such digitization refrain industries from their high business improvement potential and companies face challenges either due to human errors, lack of required skill etc... Some of these challenges can be overcome by use of proper technologies. One such technology which can widely help supply chains is Robotic Process Automation (RPA). RPA is used to automate repetitive, rule-based tasks which are done manually. RPA can save employee resources for more strategic activities as it can free employees of repetitive, monotonous tasks. This review paper discusses potential applications of RPA across various supply chain functions such as purchasing, inventory management, planning, transportation. RPA implementation itself faces barriers if industries lack required IT infrastructure, skilled employees, and lack defined operational procedures. The paper also discusses potential barriers to RPA implementation. RPA technology has proved to be reliable in substantial time savings and incorporating it in supply chain functions would greatly impact business in a positive direction.

***Index Terms*- RPA in procurement processes, Digital Readiness, purchasing, inventory management, transportation, forecasting, Order fulfillment, RPA tools, barriers to RPA.**

I. INTRODUCTION

Supply chains are the backbone of modern commerce, characterized by their complex networks of production, distribution, and logistics that require coordination and systematic execution. Traditionally, these operations have relied heavily on human labor and high manual effort, which is often prone to errors, inefficiencies, and bottlenecks.

The use of Robotic Process Automation (RPA) has brought a significant impact in various industrial sectors, notably within supply chain operations. Global supply chains have become complicated, requiring demand for increased efficiency. RPA offers a compelling solution by automating repetitive, rule-based tasks, such as data scraping, data entry, forecasting etc. thus significantly enhancing operational efficiency, accuracy, and cost-effectiveness in business processes of organization.

This review paper examines the extensive applications of RPA in supply chain operations, analyzing its transformative impact on critical areas such as inventory management, order processing, logistics, transportation, procurement, demand planning, supply planning and customer service. RPA addresses these challenges by deploying software automatic flows that can perform routine tasks with greater speed, consistency, and accuracy, thereby liberating human workers to focus on more strategic activities.

Implementing RPA in supply chain operations offers numerous advantages. The scalability of RPA solutions allows businesses to swiftly adjust to changing market demands and evolving customer requirements, thereby sustaining resilience and agility in their supply chain processes. This paper is a literature review on applications of RPA in supply chain operations, analyzing its transformative impact on critical areas such as inventory management, order processing, logistics, transportation, procurement,

demand planning, supply planning and customer service, and supporting the literature via a case study on application of RPA in procurement process improvement. This paper aims to provide a comprehensive overview of the current state of RPA applications in supply chain operations. It explores the technological advancements driving RPA adoption, the specific processes that benefit from automation, and impact on performance.

II. WHAT IS RPA?

Robotic Process Automation (RPA) is a transformative technology that leverages software robots, or "bots," operating in a certain flow of activities, to automate routine, repetitive, and rule-based tasks that are typically performed by human workers. These tasks often include data entry, transaction processing, automatic emailing, data scraping, forecast generation, responding to simple customer service inquiries etc. By replicating the actions, a human would take when interacting with digital systems, RPA enables businesses to streamline their operations, reduce errors, and free up human employees for more strategic and creative work. Robotic Process Automation has key features such as User Interface Interaction, Rule Based Decision Making, Easy Integration with existing IT infrastructure and scalability to accommodate operational uncertainties of the industry.

III. RPA APPLICATION METHODOLOGY

To incorporate RPA in a routine task involves a systematic methodology described in the following steps.

1. Process Identification: This step involves identification of tasks which can be automated based on certain rules and feasibility analysis of those tasks based on their repetitive nature, technical requirements, and impact study.
2. Process Mapping: After task identification, detailed process of how the operation is done manually is documented including each step, decision points and exceptions. The process mapping also involves the study of bottlenecks in the operation workflow for possible improvements using automation.
3. Design and Planning: This step involves specifying the requirements for the RPA solution i.e. inputs, outputs, and decision logic. Based on the requirement, a solution outline is developed, and appropriate RPA tool selection is done.
4. Development of RPA Flow / RPA bot: This process involves development of flow of actions for the RPA bot using RPA tool Writing of scripts is done to design step by step action for the bot.
5. Testing: This is the step in the process involving testing individual components of the flow to ensure they work correctly. System Integration testing is done to see if the RPA is integrated with existing IT infrastructure to do the intended job and if improvements are required.
6. Deployment: in this step, the bot / flow is moved to production in live environment to perform intended tasks.
7. Monitoring and Maintenance: This step involves monitoring of RPA flow and required maintenance activities.

IV. LITERATURE REVIEW

Potential Applications of RPA in Purchasing and Supply Management (PSM)

As competition and cost pressures rise, organizations are increasingly focusing on the digitalization of purchasing and supply management (PSM), an area that often lags other business functions. [13]

To address this, advanced digital technologies like Robotic Process Automation (RPA) are being leveraged to redesign, optimize, and automate procurement processes.[14] Key drivers of value in PSM include transaction management, process improvement, innovation, supplier capability assessment, and relationship management. However, RPA has not yet been fully integrated into current frameworks.

While technologies such as blockchain and the Internet of Things (IoT) [15] have gained significant attention in academic research, studies linking RPA to supply chain management (SCM) and PSM are still limited. Historically, PSM functions were reactive and supportive, primarily managing operational and

transactional tasks. Today, it is transforming into a strategic and integrated business function that manages the supply base. This shift requires PSM professionals to develop new skills in automation and embrace technological innovations, collectively known as “digital procurement practices.”

Organizations go through four levels of maturity in PSM digitalization. The first level involves implementing basic e-procurement systems, integrated internally and externally through electronic data interchange (EDI) and web-based applications. These systems automate structured transactional processes, leading to benefits like process simplification, efficiency gains, and cost savings.

However, as digitalization increases and customer focus sharpens, e-procurement systems reveal limitations, such as inadequate real-time data use, interoperability, and flexibility.

At the second level, organizations adopt more advanced technologies for transaction management to address these limitations and facilitate further adoption. After gaining initial experience, the third level involves establishing internal control policies and performance measures to consolidate these technologies within the company and expand their use. At the fourth level, organizations reach mature digitalization, where advanced technologies in the procurement function generate significant value and enhance external collaboration through better relationship management and supply-market awareness.

RPA technology is a cutting-edge solution driving digital transformation within Industry 4.0. The Pareto principle suggests that roughly 20 percent of a company's processes account for about 80 percent of potential improvements. For the remaining 80 percent of processes, full automation through ERP and e-procurement systems is often impractical or not cost-effective. Here, RPA can automate sub-processes.

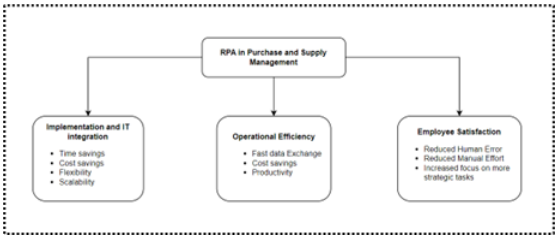
Unlike traditional Business Process Management (BPM), which relies on database-driven backend automation such as ERP and e-procurement systems, RPA integrates through the user interface. This allows the existing IT infrastructure to remain unchanged, avoiding the need for various application programming interfaces.

RPA bots access IT systems or the Internet to initiate back-office applications, copying, extracting, processing, and inserting structured or semi-structured data, performing calculations, and sending emails. RPA uses embedded functions such as HTML code, Java, and Citrix. However, RPA is not suitable for complex processes requiring decision-making based on unstructured data and should not be confused with chatbots, which automate conversational front-office processes.

Vendors like UiPath, Blue Prism, and Automation Anywhere are addressing RPA's limitations by integrating it with artificial intelligence (AI) technologies, such as machine learning, natural language processing, and computer vision.

RPA impacts procurement in operational (e.g., time savings, efficiency gains), organizational (e.g., new roles for employees), and relational (e.g., buyer-supplier relationships) aspects. The benefits of RPA for procurement departments include quick and straightforward implementation and savings in employee costs and time.

RPA application in PSM face certain barriers in industry. Barriers include lack of EDI connected IT systems which help in easy RPA implementation, Data inconsistencies, system changes and updates etc. However, RPA can be adopted on a smaller scale in such industries along with manual operations which would still result in time savings.



Potential Applications of RPA in Transportation and Logistics in Supply Chain

Data is at the heart of logistics firms, and robotic process automation in transportation and logistics may

streamline processes, reduce overall operating costs, and increase efficiency and productivity. The logistics sector is undergoing a radical transformation due to the widespread use of robotic process automation (RPA). Businesses are using RPA in transportation to streamline the process of managing shipments to customers all around the globe from central hubs. Transportation management and many cost and efficiency benefits may be made via the usage of RPA. Advantages of RPA in Transportation and Logistics include time and cost savings as RPA may be utilized to speed up the completion of labor- intensive tasks, which saves time and money for organizations by shortening the duration of the whole process cycle. As a result, people are able to focus their efforts on more strategic tasks , minimization of human error as Robotic process automation (RPA) drives processes to record and manage themselves, making it simple to determine the cause of issues and implement fixes, productivity enhancement as Robots that are part of a Robotic Process Automation (RPA) system may be seen of as a company's permanent workforce; using preprogrammed models, these robots consistently and accurately carry out their assigned tasks. Because of this, a company's productivity increases, and it can function at a better level when there is complete dependability and precision and a high quality of work.

If a logistics firm wants to keep its customers happy, it must master the art of email communication. Whenever an order is received, processed, sent, or delayed, RPA may automatically notify customers. As a result of RPA's efforts to streamline business processes, interactions between companies and their customers have improved, leading to higher levels of customer satisfaction, more efficient management, and higher profits. Product information must be readily available for everyone from upper management to employees to assistants to advisers to customers. Due to the number of people involved, the transportation chain sometimes has difficulties in communicating. The appropriate authority may not be able to communicate with the selected employee. RPA technologies, such as a chat bot with automated responses, may be used to address this issue.

RPA technologies may periodically notify the appropriate parties by sending them email or push notifications with the latest information. In the same vein, chat bots may respond to customers' inquiries regarding their orders, shipments, and any delays they may have, as well as any other concerns they may have concerned the ordering process.

The use of RPA software streamlines the report making process. Numerous reports, including those detailing the processing of orders, the receipt of payments, responses from customers, and revisions to transportation infrastructure, are generated on a regular basis in the transportation business. Reporting on a wide variety of frameworks for statistical purposes may be a time consuming, error-prone process. With the use of AI, RPA systems can automatically compile reports from data. From the input information, the program may automatically pull the relevant facts to include in the report. When an RPA system is used to create the report, there is far less need for human intervention. Since RPA frees up so much manpower and materials, it can be put to better use elsewhere.

Potential Applications of RPA in Inventory Management

Inventory Management in a supply chain is a mix of various operations such as improved inventory tracking and management, enhanced demand forecasting and replenishment, streamlined order processing and fulfillment, and increased regulatory compliance through automated documentation and reporting. Industry supply chain encompasses the planning, execution, and control of all activities involved in the movement of materials and information, beginning from the procurement of raw materials, and extending to the final delivery of products to customers. This includes various entities such as manufacturers, suppliers, warehouses, transportation companies, distribution centers, and retailers.

The value chain enables companies to create distinctive customer products and experiences, employing strategies to deliver unique added value and gain a competitive edge. Consequently, the supply chain aims to enhance profitability and provide superior customer experience by ensuring accurate inventory management and availability of products. In

essence, the supply chain encompasses functions such as product development, marketing, operations, distribution, finance, and customer service.

Potential Applications of RPA in Payments and Order Processing

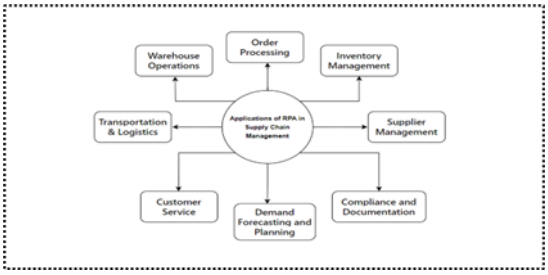
Order Placement and payments processing are critical aspects in a supplier – customer relationship in a supply chain. Order processing includes selecting products, financing, and confirmation of order placement. Small scale industries may still be dependent on manual paperwork for this procedure having a wide scope for automation and digitization using RPA saving costs and time for these industries. Information can be directly transferred from payment interfaces to databases of both supplier and customers, Email automation helps in automatic confirmations about the transactions, automation can also help in updating the stock levels as part of inventory management after a commodity is supplied to the customer.

Potential Applications of RPA in Vendor Management / Supplier Management

RPA can help in automating manual selection of vendors for operations like site balancing and order processing to optimize logistics cost and saving time. MNC's like Dell, HPE, Cisco have suppliers across countries. When customers require urgent part supply, the material management teams must allocate the quantities of requested commodities among the customers to fulfill the needs in an optimized manner. This process has several steps such as preparation of quotation, vendor communication and distribution, analysis of transaction documents such as sales order requisition, sales order, purchase order requisition, purchase order, custom clearance invoices, global trade compliances documents and many more. This document verification and scraping necessary data from the invoices such as order dates, delivery dates, prices, county of origin can be scraped for business use using RPA as doing all these tasks manually can be time taking and unproductive. RPA tools can easily integrate with ERP, SRM, CRM software for automating, updating of data for further processes.

Potential Applications of RPA in Supply and Demand Planning

For Supply and Demand planning, employees must collect data, compile, and find insights before communicating about the planning strategies to senior management. This process can be easily automated by RPA using Excel Macros or VBA. Python scripts can be prepared to automate such processes which is highly recommended these days because of high flexibility to incorporate changes in the code due to changes in the supply chain and business environment.



IV. REVIEW METHODOLOGY

The methodology for this literature review on the application of Robotic Process Automation (RPA) in supply chain management encompasses a structured and systematic approach to ensure comprehensive coverage and rigorous analysis of existing research. The methodology is outlined in the following steps:

Defining Research Questions and Objectives

The first step involves defining clear research questions and objectives to guide the review process. Key questions include: What are the primary applications of RPA in supply chain management? What benefits and challenges are associated with RPA implementation in SCM.

Literature Search Strategy

A comprehensive literature search was conducted using multiple academic databases and sources to ensure a wide range of studies were considered. The databases include:

Google Scholar, Scopus, IEEE Xplore, Elsevier (Science Direct), SpringerLink Keywords used for the search included combinations of terms such as "Robotic Process Automation," "RPA," "supply chain

management," "automation," "logistics," "inventory management," "procurement," "demand forecasting," and "supply chain integration."

Inclusion and Exclusion Criteria

To ensure relevance and quality of the reviewed literature, specific inclusion and exclusion criteria were established: Inclusion Criteria:

Peer-reviewed journal articles, conference papers, and reputable industry blogs and reports. Publications from the past five years (2019-2023) to capture recent advancements and trends. Studies that focus explicitly on RPA applications in supply chain management.

Exclusion Criteria: Non-peer-reviewed articles, opinion pieces, and editorials. Studies focusing on RPA applications outside the supply chain domain. Articles not available in English.

Reporting and Discussion

The results of the literature review were systematically reported, providing a comprehensive overview of the current state of research on RPA in supply chain management. The discussion section addressed the research questions, highlighted key insights, and identified areas for future research. By following this structured methodology, the literature review aimed to provide a thorough and balanced assessment of the application of RPA in supply chain management, offering valuable insights for both academia and industry practitioners.

Tools and Techniques used in RPA

Implementation of automation flows is done by various software tools and scripting languages. Software tools include prominent tools like UI Path, Automation Anywhere, Blue Prism, Microsoft Power Automate etc. The tools are widely used in supply chain management across various industries. While RPA platforms often provide their own scripting or workflow languages, the integration of programming languages can enhance the capabilities and flexibility of RPA solutions.

Python is widely used in RPA, mainly due to its versatility, extensive libraries, and ease of use. Python scripts can be integrated into RPA workflows to perform various tasks such as data manipulation, web scraping, file handling, and interacting with APIs. Additionally, Python can be utilized for machine learning and natural language processing tasks, which can enhance the intelligence of RPA bots.

JavaScript is commonly used for web automation tasks within RPA processes. It can interact with web elements, perform actions on web pages, extract data, and handle asynchronous events. JavaScript frameworks like Selenium WebDriver or Puppeteer are often used in conjunction with RPA platforms to automate web-based processes.

Java is used in RPA for building custom libraries, extensions, or integrations with enterprise systems. Many RPA platforms provide Java SDKs or APIs that allow developers to extend the functionality of bots or integrate with existing Java-based applications.

RPA platforms like UiPath primarily use C# for building automation workflows. C# provides strong integration with the Microsoft ecosystem, making it suitable for automating tasks in Windows environments and interacting with .NET-based applications.

Although less common in modern RPA implementations, VBScript (Visual Basic Scripting Edition) is still used in some legacy systems or for automating tasks in Microsoft Office applications. However, its usage is declining in favor of more modern and versatile languages like Python or JavaScript.

Structured Query Language (SQL) is used within RPA processes for interacting with databases, querying data, and performing data manipulation tasks. SQL commands can be integrated into RPA workflows to extract, update, or manipulate data stored in relational databases.

For automating tasks on Unix/Linux systems, shell scripting languages like Bash are used within RPA processes. Shell scripts can execute system commands, manipulate files, automate administrative tasks, and interact with other applications or services running on the system.

RPA bots can extract data from various sources such as emails, documents, and websites. Optical Character Recognition (OCR) technology is often used to interpret data from scanned documents.

V. CHALLENGES IN RPA ADOPTION IN INDUSTRIES

There are various challenges in the adoption of RPA adoption as in many industries the supply chains include complex processes because of lack of resources. Process standardization is required in every step of RPA implementation. Too much complexity increases operational costs and disruptions. Another challenge involves lack of proper IT system integration between suppliers and customers via EDI connections. Challenges might include training of employees for necessary changes in the automation according to changes in business, addition of new vendors or company inventory hubs, customers etc. Another challenge includes potential data breach or privacy issues. However, these challenges can be easily tackled by the increased ROI of automation implementation and results in long-term productivity and profitability enhancement of the organization.

CONCLUSION

The application of Robotic Process Automation (RPA) in supply chain management represents a transformative shift that holds significant promise for enhancing efficiency, accuracy, and adaptability. Through this comprehensive literature review, it is evident that RPA's ability to automate repetitive and rule-based tasks offers substantial benefits, including cost reduction, improved operational efficiency, and enhanced data accuracy. Key areas of impact identified include inventory management, order processing, demand forecasting, procurement, and logistics.

Moreover, the integration of RPA with other advanced technologies such as Artificial Intelligence (AI), Machine Learning (ML), and Internet of Things (IoT) amplifies its potential, enabling more intelligent and responsive supply chain operations. These synergies facilitate real-time data analysis, predictive maintenance, and adaptive supply chain strategies, thereby driving competitive advantage.

Despite the promising benefits, literature also highlights several challenges and limitations. Implementation barriers such as high initial costs, resistance to change, and the need for ongoing maintenance and updates are notable concerns. Additionally, the complexity of supply chain processes requires careful planning and customization of RPA solutions to ensure seamless integration and optimal performance.

RPA is poised to revolutionize supply chain management by automating routine tasks and enhancing overall operational efficiency. While challenges remain, the strategic implementation of RPA, coupled with continuous innovation and adaptation, can unlock significant value, and drive the evolution of supply chains towards greater resilience and agility.

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