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RESEARCH ARTICLE

Streamlining Engine Parts Procurement in Agricultural Machinery: Integrating ECRS and Digital Lean Concepts in Thailand's Industry

Supanida Auesiritrakul[1], Panutporn Ruangchoengchum[2*]

[1,2]College of Graduate Study in Management, Khon Kaen University, Khon Kaen, Thailand

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***Corresponding Author:**
rpanut@kku.ac.th

ABSTRACT

This research primarily investigates the causal factors of waste resulting from delays in the parts procurement process for medium-sized engine manufacturers in Thailand and seeks to develop guidelines for reducing such waste by applying the ECRS (Eliminate, Combine, Rearrange, Simplify) and digital lean concepts. Utilizing a mixed-methods research design with a deductive approach, the study explored the procurement processes of engine parts for agricultural machinery. A purposive sample of 160 participants involved in the procurement process from the Eastern Region of Thailand was carefully selected to ensure robust model validation through Multiple Regression analysis. The methodology encompassed quantitative methods utilizing a structured questionnaire developed from existing literature on procurement waste. This was complemented by qualitative methods, including direct observations timed with a stopwatch and in-depth interviews with 10 key informants. The study revealed significant inefficiencies within the procurement process, notably prolonged lead times which were successfully reduced from 342.49 minutes to 280.69 minutes per order, thereby achieving a daily time saving of 518 minutes. The improvements were realized through strategic waste elimination and process optimization, incorporating digital Lean and ECRS strategies. These strategies not only simplified the procurement steps but also effectively addressed and eliminated the cumbersome and slow approval processes that had previously involved multiple approvers and extensive approval times. This research demonstrates the effectiveness of applying Lean management principles and digital technologies to enhance procurement efficiency. The significant reductions in waste and lead time underscore the direct benefits of these approaches, highlighting their potential for broader application across various sectors to optimize business operations.

INTRODUCTION

Procurement and purchasing functions are critical to an organization's continuity and efficiency. These activities serve as the lifeline, ensuring a steady flow of raw materials, tools, and equipment vital for production and service provision, much like blood

nourishing an organism (Mebrate & Shumet, 2024). Accuracy, timeliness, quantity, location, and cost are crucial parameters that define the success of these functions. Issues often arise in procurement due to the complex role of the buyer, who must coordinate between the organization and raw material suppliers within the supply chain. This coordination is pivotal in connecting the diverse sources of raw materials to support organizational operations and drive success. Optimizing this flow of materials and information between trading partners is essential for responding effectively to customer needs.

It is said to have attracted global concern; hence the subject of reforms, restructuring, rules, and regulations (Kabega et al., 2016). Carr and Smeltzer (1997) affirm that procurement practices include all the steps that the organization takes in purchasing to supply or integrate the organization's performance for productivity enhancement through cost and time reduction. Thus, the human resource best practices are of importance to organizational success, especially in the linkage of procurement to organizational performance. Various public institutions, including developed and developing countries, have instituted purchasing reforms involving laws and regulations (Kabega et al., 2016).

Effectiveness of the procurement process to the organization lies in sound business practices that harness the maximum value for the organization through the acquisition of goods and services. This follows the adage that the purchasing department's role is to deliver the right material or service in the right amount to the right place at the right time and at the right price (Sollish & Somanik, 2005). The application of appropriate procurement practices strategically has the potential impact on the performance of organizations and national economies in general (Keith et al., Citation2016). However, Singhal and Hendricks (2011) observe that disruptions in purchasing practices devastate organizational performance at whatever level.

In practice, the economic tool of guaranteeing national development involves the purchasing process when it is well laid out for implementation. Many low-income countries are challenged by the dynamic purchasing revolution, and this gives them the working difficulty in procurement and performance together with the inside and outside dealings (Wambui et al. 2017). Jibrin et al. (2014) noted that, in the current procurement industry, the main problem is not with the narrow regulation models, but this is because of non-compliance and pitiable execution.

As depicted in Figure 1, the purchasing process involves multiple departments, both internal and external to the organization, and has grown increasingly complex. This complexity leads to longer procurement cycles, an abundance of paperwork, and subsequent delays in delivering products and raw materials to customers, impacting both internal operations and external customer satisfaction.

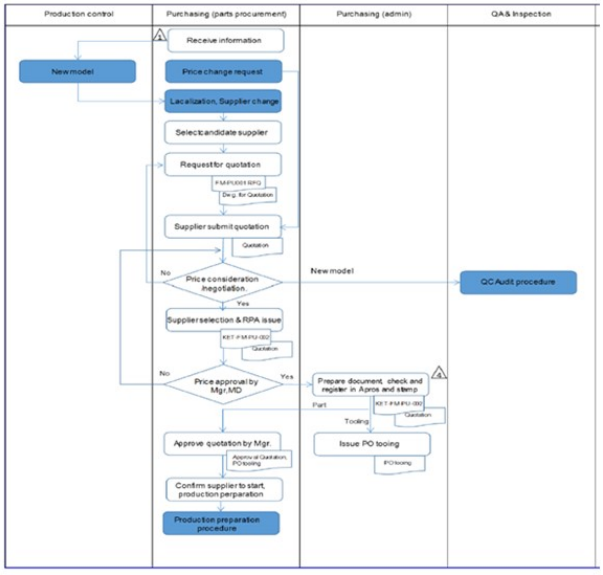

Figure 1: The purchasing system

The agricultural machinery industry, particularly in Thailand, is increasingly significant. In 2023, Thailand's agricultural product exports are projected to grow by approximately 1.6 to 5.6 percent year-over-year, reaching a value of between 84,600 and 87,900 million baht. This growth is accompanied by intense competition, driven by the diversity of agricultural products and advancements in technology tailored to consumer demands. To remain competitive, industry players must innovate continuously, developing new products and technologies while simultaneously reducing manufacturing costs.

A prime example of industry adaptation is Kubota Engine (Thailand) Co., Ltd., which was established on February 24, 2011, and began full-scale engine production in October 2012. As a key player in international engine production, it supports Kubota's global business expansion, delivering engines across Thailand, Southeast Asia, and even to markets in East Asia, America, and Europe (Allioui & Mourdi, 2023). The company leverages an integrated production system, receiving raw materials from Siam Kubota Metal Technology and supplying finished engines to Siam Kubota Corporation, which enhances its competitiveness in the engine market.

Despite these advancements, the company faces challenges such as errors and delays in the parts purchasing process, which can disrupt production schedules and delay customer deliveries. Consequently, research is underway to address these issues, aiming to enhance efficiency through the application of advanced procurement methodologies (Allioui & Mourdi, 2023). Prior studies have utilized tools like flow process chart analysis and digital lean concepts to minimize waste and streamline operations. This research seeks to further these efforts by integrating the ECRS and digital lean concepts specifically for the procurement of engine parts in the agricultural machinery sector. The anticipated outcome is a more efficient process that not only reduces costs but also serves as a model for similar improvements in other sectors (Dwivedi et al. 2022).

The investigation by Althabatah et al. (2023) clearly indicates that technologies of Industry 4.0 have continued attracting great interest, especially e-procurement and block-chain. These technologies have various values that they add to the organizations. They include supplier evaluation, lead time reduction, optimization of costs, and improved security for organizational data. This research unveils some of the pivotal trends and insights deemed critical for the evolution of Procurement 4.0, illuminating a way forward towards the quest for more efficiency and value addition in supply chain management.

The research by Corbos et al (2023) found that a high level of strategic procurement performance 4.0, together with high circular economy openness, makes organizations realize the highest level of competitiveness. However, a low level of circular economy openness made organizations record similar low levels of competitiveness, whether organizational performance in strategic procurement 4.0 was on a low or average level. So, it has been evidenced that strategic procurement 4.0, when translated into alignment with sustainability goals and incorporating digital technologies in the process, ensures a higher level of competitiveness within the conditions of the circular economy, as was revealed and outlined within the Romanian business environment.

Tripathi and Gupta (2021) found a redesigned procurement framework that offers radical improvements in several key areas. These would include cost and cycle time reductions, less human effort, a higher degree of automation, and better traceability. It also increases the easiness of access to information and decreases uncertainty with the process of procurement. These improvements are backed up by the right blend of emergent technologies and a methodical approach to process redesign, pointing toward substantial gains for supply chain management in Industry 4.0.

Objectives

Following are the main objectives of this research:

- To determine the causal factors of waste caused by delays in the parts procurement process of medium-sized engine manufacturers in Thailand.
- To propose guidelines for reducing waste caused by delays in the parts purchasing process of medium-sized engine manufacturers in Thailand by applying ECRS and the digital lean concept.

LITERATURE REVIEW

ECRS stands for Eliminate, Combine, Rearrange, and Simplify. It's a lean approach that systematically reviews processes to identify and eliminate waste, streamline operations, and enhance productivity. Specifically, the ECRS framework encourages the review of all process steps to determine their necessity, combine tasks that can be efficiently executed together, rearrange steps to optimize workflow, and simplify tasks to make them more straightforward (Perdomo-Verdecia, 2022). This methodology is particularly relevant in settings like Thailand's agricultural machinery industry, where reducing complexity and waste can lead to significant cost savings and faster response times.

Digital lean transformation

Digital lean extends the principles of traditional lean methodologies by incorporating digital technologies such as IoT, big data analytics, and artificial intelligence. These technologies enhance the visibility and control of the procurement process, allowing for better decision-making and more efficient management of resources (de Oliveira-Dias et al. 2022). For instance, integrating high-frequency machine data with production schedules can optimize the timing and quantity of parts procurement, thus minimizing inventory costs and reducing waste. Moreover, digital tools can facilitate predictive maintenance, which not only prevents equipment failure but also ensures that the procurement of parts is timely and based on actual needs rather than estimates (Rojeck et al. 2023).

Synergy and implementation in Thailand

The synergy between ECRS and digital lean provides a powerful framework for improving the procurement processes in Thailand's agricultural machinery sector. By implementing ECRS, companies can streamline their processes to eliminate redundancies and inefficiencies. When coupled with digital lean, this streamlined approach is enhanced by data-driven insights that can further optimize procurement logistics, supply chain management, and inventory control (Motaunget al. 2023). The adaptation of these integrated practices in Thailand could lead to improved production efficiency, reduced lead times, and better alignment with market demands, which are crucial for maintaining competitiveness in the global market.

Cultural and economic impacts

The cultural shift towards a more data-driven, efficient operational model promotes a culture of continuous improvement and innovation within the sector. This transformation is not just about technology adoption but also involves training and development, fostering a mindset that embraces change and innovation. The economic impact of such a transformation can be profound, leading to better resource utilization, reduced costs, and enhanced competitive advantage, which is vital for Thailand's agricultural sector that plays a crucial role in the national economy (Omol, 2023).

In conclusion, the integration of ECRS and digital lean into the engine parts procurement processes for agricultural machinery in Thailand represents a significant opportunity to enhance operational efficiencies and drive economic value in a crucial sector. These methodologies, while distinct, are complementary and, when implemented together, can transform traditional practices into a modern, responsive, and efficient system. Engaging third parties to secure critical goods and services is instrumental in actualizing business objectives at the right cost and efficient level. This dimension of procurement demonstrates how important procurement is in optimizing the supply chain and effectively managing the cost for furthering a more strategic role of purchasing within corporate frameworks (Alhammadi et al. 2023).

In the manufacturing sector, procurement strategies come almost close to mirroring production efficiency principles, more so those highlighted in lean manufacturing. This would ensure minimized defective outputs, just-in-time inventory management not to overstock, and ensure that the production process is lean with value-adding activities (Moshood et al. 2021).

They are what form the bedrock of lean procurement: minimization of waste and maximization of value within a supply chain context. Taiichi Ohno identified the eight wastes (defects, overproduction, waiting, underutilized human talent, transportation, inventory, motion, and processing), which provides a structured framework with regard to inefficiency analysis within the procurement process (Tasdemir &

Gazo, 2018). Most importantly, procurement should be based on the lean principles integrated with digital methodologies, particularly the ECRS (Eliminate, Combine, Rearrange, Simplify) model approach to resources. This modern research, therefore, applies these methods in dissecting and finding the solutions to the inefficiencies of procurement and making a call for digital reformation, which meets modern demands. Through the use of digital tools and analytics, procurement professionals could make better decisions, enable supplier collaboration, and eventually achieve a sustainable competitive advantage (Dubey et al. 2023). Not only does this strategic reorientation cement the role of procurement as a critical business function, but it also underlines its leverage to deliver organizational success through innovation and strategic foresight.

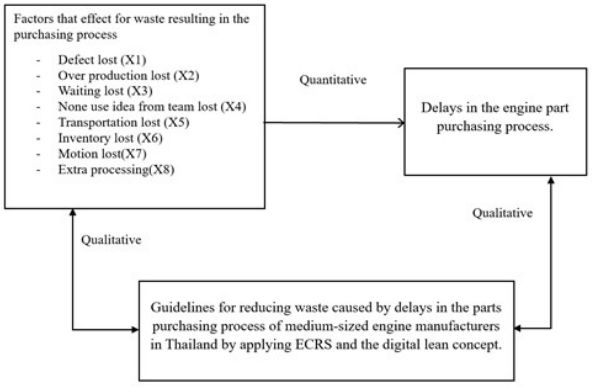

Figure 2: Conceptual framework

METHODOLOGY

The mixed research design from the deductive approach was actually adopted to carry out an investigation into the waste in the procurement process of engine parts for agricultural machinery. Such a design sought data collection that presents itself with both a qualitative and quantitative nature to generate a general perspective of issues under investigation and suggest ways for strategies toward effective waste reduction.

Sample

The participants will be purposively sampled from among individuals working within the procurement process of engine parts for agriculture machinery in the Eastern Region of Thailand. The sample size would be, however, 160 participants, as it is a reasonably large number for assuring that the model gets validation through Multiple Regression analysis.

Instruments

The main tool used in collection of quantitative data was a structured questionnaire developed from extant literature and theories on areas of waste in procurement related to the study under consideration. In this section, the questionnaire was divided into two categories, the first part was related to basic demographic information (5 items), and the other part covered issues of waste and delays in the procurement process (10 items) based on the issues that were measured on a 5-point Likert scale. The study included using a stop-watch to time activities within the procurement process and carrying out in-depth interviews with the (key informants) in the process.

The questionnaire face validity was anchored on its development from established studies and theories.

The cronbach's alpha Coefficient was found at 0.83 during pilot testing, indicating good internal consistency. In this case, it was used in the establishment of standard and qualitative data collection methods, which are replicable and consistent in different settings.

Data collection for the quantitative approach was through the use of questionnaires, and qualitative data collection entailed direct observations timed for the procurement activities. Most of the secondary data is sourced from academic documents, case studies, and business reports for the context of the procurement delays.

Data collection

The questionnaire was prepared to distribute among the selected participants who are dealing directly with the procurement process. The collected data will point out the causal factors of waste in this category from the perception of the participants.

Qualitative data collection

This section presented primary and secondary data of the study. Primary data is that data collected under direct observation of this study and timing of procurement activities. Secondary data were sourced from available records and documents. The in-depth interviews were conducted among 10 purchasing engineers key informants in order to get detailed information on the procurement activities.

Data analysis

In this study, the Ordinary Least Square Method (OLS) for Multiple Regression Analysis was used to find out the significant factors affecting waste in the procurement process. The data used in analysis were obtained through surveys to assess the effect of the identified variables on the efficiency of the procuring entity.

The data obtained from observations of the participants and the transcripts of the audio-taped interviews were subjected to content analysis. Others include the process flow charts and time-based work charts used in the visualization and analysis of the flow and duration of activities from the time goods and services begin their procurement process to the identification of value-adding, non-value-adding but essential, and purely non-value-adding activities. This approach was providing the appropriate skeleton through which the procurement process was going to be analyzed; therefore, through identifying the key critical waste factors, development of strategies to minimize them. This approach was one of the ECRS (Eliminate, Combine, Rearrange, Simplify) model and digital lean concepts to enhance efficiency.

RESULTS

Table 1: Relationship of causal factors on the waste in the purchasing process

Factor	Description	Correlation Coefficient
Defect Loss	Losses from having too much waste	1.032
Waiting Loss	Losses due to waiting time	1.536
Transportation Loss	Losses due to unnecessary transportation	0.692
Extra Processing Loss	Losses from having too much processing	0.775

Table above summarizes the results of the analysis of the influence of causal factors on the waste in the purchasing process using Multiple Regression Analysis with the Ordinary Least Square (OLS) method. These results indicate the extent to which each factor impacts the waste in the purchasing process, with the correlation coefficients providing a quantitative measure of their influence table 2.

Table 2: Result of factors (work process) that affect the waste of the purchasing process

Waste	*b*	*SE*	*t*-Stat	*p*-Value
Constant	0.414	0.135	2.623	0.061
Defect lost (XI)	1 032	0 593	3 163	0 031*
Overproduction lost(X2)	0.326	0.212	1.596	0.235
Waiting lost(X3)	1.536	1.12	3,362	0.000**
None use idea from team lost(X4)	0 1 12	0 036	1 032	0 563
Transportation lost(X5)	0.692	0.263	2.965	0.040*
Inventory lost(X6)	0.843	0.426	3.012	0.035*
Motion lost(X7)	0.011	0.075	1,102	0.626
Extra processing(XS)	0.775	0.523	2.989	0.341*

R-Square = 0.752 , Adjusted R-Square = 0.723 , *F*-Stat = 25.032 Sig.=0.000

Next step, collect data for analyzed current situation of process and find waste process. It was found to consist of 13 main activities, starting from Data detection of new model, selecting a Supplier to request a quotation, buyer sending a request for quotation (RFQ) to the supplier, buyer checking the quotation, compare prices and select a supplier, prepare documents to request price approval for department managers and the company president to approve, Record the approved price into the purchasing system. Procurement officers check system prices. The purchasing officer stamps the company seal on the quotation and sends it to the department manager, purchasing officer send price confirmation documents back to supplier to confirm production, supplier ships parts to the company, product inspection by quality assurance department, the parts are entered into the engine production line,

the seller sends a quotation back to the buyer.

When analyzing the value of activities (VA), activities that add value were found, including price comparison and supplier selection activities, preparing documents to request price approval (Price approval) for department managers and the company president to approve. Record the approved price into the purchasing system. The purchasing officer sends price confirmation documents back to the Supplier to confirm production. Deliver parts to the company, Part inspection, supply parts into the engine production line. In addition, activities that do not create value (NVA) were found, including the activity of choosing a supplier to request a quotation, Buyer checking the quotation. Procurement officers check system prices. The purchasing officer stamped the company seal on the quotation to send to the department manager. It was also found that activities that create value but are necessary (NNVA) include the activity of receiving information, new model Buyer, Requesting Quotations (RFQ).

ACTIVITY (ACTIVITY CODE)	VALUE ANALYZED	DISTANCE (KM)	TIME (MINS)	KEY INFPRMANT	SYMBOLIC
1.DATA DETECTION (A1)	NNVA	-	10.25	PHE	
2.SELECT SUPPLIER FOR QUOTATION (A2)	NVA	-	12.14	PHE	
3.Buyer SEND DETAILS FOR QUOTATION TO SUPPLIER (A3)	NNVA	-	7.34	PHE	
4.Buyer CHECK QUOTATION (A4)	NVA	-	5.28	PHE	
5.COMPARE PRICE AND SELECT Supplier (A5)	VA	-	41.24	PHE	
6.MAKE A DOCUMENT REQUESTING PRICE APPROVAL FOR THE AUTHORIZED PERSON TO APPROVE (A6)	VA	-	120	PHE	
7.RECORD THE APPROVED PRICE INTO SYSTEM (A7)	VA	-	5.04	PHE	
8. SYSTEM PRICE PRICE CHECK BY PROCUREMENT CLERK (A8)	NVA	-	1.04	PHE	
9.PROCUREMENT CLERK STAMPS THE COMPANY IN THE QUOTTION TO SEND FOR MANAGER SIGN (A9)	NVA	-	0.58	PHE	
10.PROCUREMENT CLERK SEND PRICE CONFIRMATION BACK TO SUPPLIER (A10)	VA	-	4.08	PHE	
11. SUPPLIER DELIVERY PART TO FACTORY (A11)	VA	120	87.65	PHE	
12.PART INSPECTION BY QUALITY ASSURANCE DEPARTMENT (A12)	VA	-	32.65	PHE	
13.SUPPLY PART TO PRODUCTION (A13)	VA	0.05	15.2	PHE	
TOTAL		120.05	342.49		7 2 4 - -

Figure 3: Measurement model

In addition, when analyzing the waste caused by delays in the parts purchasing process according to Figure 3, it was found that the engine parts purchasing process took a total of 342.49 minutes, which exceeds the standard of 320 minutes. Delivering parts to the company took as much as 87.65 minutes, followed by price comparison and supplier selection activities, which took a total of 41.24 minutes.

When the activities in the engine parts purchasing process are linked together makes it possible to see an overview of the flow in the engine parts procurement process. By analyzing time-based work diagrams between the production planning department until work was entered into the production department, it was found that the engine parts procurement process took as long as 342.49 minutes (as shown in Figure 3). It can be seen that the time-based work diagram analysis This makes it possible to find activities that do not create value.

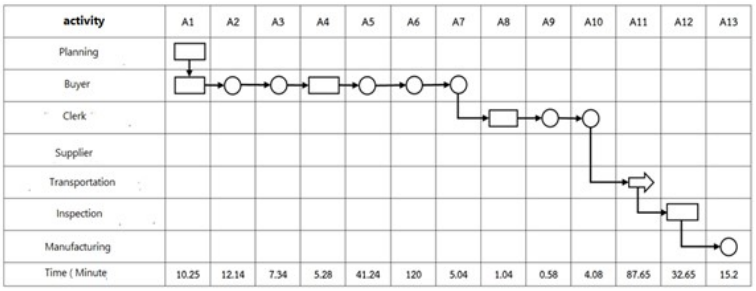

Figure 4: Time-based flowchart of the engine parts procurement process

Guidelines for reducing waste caused by delays in the parts purchasing process of medium-sized engine manufacturers in Thailand by applying ECRS and the digital lean concept.

From the results of the data analysis, activities within the purchasing process and analyzed with the result of factor that get the result from questionnaires can be classified according to ECRS principles by analyzing and classifying each activity as follows:

Eliminating

The analysis results found that work that does not create value and is wasted. It was found that in the part of order approval It has proposed ways to increase the range of order values for approvers to have a more comprehensive value framework. For example, orders worth 10,000 - 50,000 dollars used to use three approvers when increasing order approval authority. such purchase There will be only 2 approvers left. By proposing this approach, in addition to reducing the power of any one approver, it also expands the power of the approver so that improvement by add scope of approval authority and Relevant personnel will decrease.

Combining

It brings together related and interconnected processes to make the process work faster and can reduce redundant steps. It was found that in the part of transportation, so it was improvement by combine the rout for receiving part from any route to 1-2 route for received part from supplier.

Simplifying

The analysis result found process waiting quotation is the waiting lost process, so it is improvement by apply digital lean techniques for reducing process waiting quotation from supplier by create the new program for supplier bidding part price in system.

ACTIVITY (ACTIVITY CODE)	VALUE ANALYZED	DISTANCE (KM)	TIME (MINS)	KEY INFPRMANT	SYMBOLIC
1.DATA DETECTION (A1)	NNVA	-	10.25	PHE	
2.SELECT SUPPLIER FOR QUOTATION (A2)	NVA	-	12.14	PHE	
3.Buyer SEND DETAILS FOR QUOTATION TO SUPPLIER (A3)	NNVA	-	7.34	PHE	
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TOTAL		120.05	342.49		7 2 4 - -

Figure 5: Flow of wasted activities in the engine parts purchasing process

From Table 3 as below, the approval of order issuance can be explained as follows.

1. Order value of $50000 or more is approved by only Authorizer 1.
2. Order value ranging from $50,000 – $100,000 is approved by No. 1 and No. 2 approvers respectively.
3. Order value ranges from $100,000 – $150,000 approved by 1st, 2nd, and 3rd approvers.
4. The value of the order is $150,000 or more. Approved by approvers No. 1 – 5 respectively.

Table 3: PO after improvement

Amount Approval	<50K	50K – 10K	100K – 150K	>150 K
Requestor's Manager	x	x	x	x
Site Controller		x	x	x
CFT Director			x	x
SVP or VP of Ops				
VP of Finance				x
EVP Operations				x

The table above indicates a tiered approach to financial approvals, where higher amounts require higher levels of seniority or specialization to authorize, ensuring checks and balances within financial operations.

Table 4: Average comparison results before and after the improvement

Improvement	Before	After	Changes
Number of activities	13	12	Activity decreased
Total time in the activity	342.49 Mins	280.69 Mins	Time spent on activity decreased
Relevant personnel	12	7	Scope of approval authority has increased

There were 13 activities involved in the process. The number of activities was reduced to 12. This decrease in the number of activities suggests a streamlining of the process, which may have eliminated redundant or unnecessary steps, thus enhancing efficiency. The total time spent on activities was 342.49 minutes. It decreased to 280.69 minutes (Table 4). The reduction in total time by 61.8 minutes indicates a significant improvement in process efficiency. 12 personnel were involved in the approval or execution of the process. Which were reduced to 7 later on, which demonstrates an increase in the scope of approving authority.

DISCUSSION

The present research devised improvement strategies such as robustness in purchasing operations and a significant reduction of waste have, therefore, leveraged the overall operational efficiency and effectiveness of the procurement function, setting a precedent for a wider application of lean management principles and digital technologies across other sectors of the company. The study had managed to show the ways through which the procurement process, for example, had managed to cut down the lead times from 342.49 minutes per order to 280.69 minutes, saving 518 minutes per day. This was made possible by focusing on waste elimination and process streamlining. The study went further to simplify procurement steps by avoiding unnecessary delays through the integration of Lean principles and ECRS strategies in the procurement process. Example long and repetitive approval processes that are slow because many approvers are involved and the approval times are long. It shows that the contemporary study does not only underline direct benefits from Lean applications in enhancing purchasing efficiency but the very possibility of replicating these strategies to further optimize business operations in all areas.

The comparative analysis of the findings from Althabatah et al. (2023), Corbos et al. (2023), and Tripathi and Gupta (2021) with this study reveals both congruence and divergences in the transformative impacts of Industry 4.0 technologies on procurement processes. Like Althabatah et al. (2023), this study highlights the critical role of e-procurement and blockchain technologies in enhancing operational efficiencies, such as supplier evaluation and lead time reduction, which are fundamental to the evolution of Procurement 4.0. Both studies recognize the added value these technologies bring to organizational operations, driving forward innovation and efficiency. Corresponding to the findings of Corbos et al., this research also underscores the integration of digital technologies with strategic procurement practices as a means to achieve higher competitiveness. Both studies illustrate how aligning procurement strategies with broader sustainability goals and digital advancements can substantially enhance competitive standings within the market. Tripathi and Gupta's insights into the redesign of procurement frameworks to include automation and better traceability resonate with this study's approach to streamlining processes. Both investigations advocate for minimizing human intervention and optimizing process flows, highlighting substantial improvements in procurement efficiency. Unlike Corbos et al., who delve into the circular economy's role in enhancing procurement performance, this study does not specifically address the circular economy principles. This difference might stem from the distinct industrial and regional focuses of the studies, suggesting that the relevance of the circular economy may vary across different business environments. While Tripathi and Gupta (2021) focus broadly on cost and cycle time reductions across various procurement activities, this study specifically targets waste reduction and lead time improvements in the procurement of engine parts for agricultural machinery. The more focused application in this study might reflect a more tailored approach to specific industry needs compared to the broader, more generalized improvements suggested by Tripathi and Gupta.

The differences in focus areas such as circular economy principles might be due to the specific

industries and operational contexts addressed by the different studies. Geographical factors and regional business practices could influence how procurement strategies are developed and implemented, as seen in Corbos et al.'s emphasis on the Romanian business environment (Vogiantzi et al. 2023; Cader et al. 2024). Variations in the level of technological integration and maturity across different organizations could account for differences in how digital technologies are leveraged for procurement enhancements (Harju et al, 2023). These comparisons illustrate how the integration of Industry 4.0 technologies can be adapted to various business contexts, emphasizing the need for strategic alignment with corporate goals and sustainability initiatives to maximize the benefits of digital transformation in procurement (Machado et al. 2024). Both this study and others underscore the potential for these technologies to drive innovation and improve competitive standings by aligning procurement strategies with broader sustainability goals and digital advancements. However, unlike some studies that explore the role of the circular economy in procurement, this research does not delve into these principles, possibly due to its specific focus on the agricultural machinery sector, which might have different operational demands and contextual needs compared to other industries covered in the comparative studies. This detailed analysis and strategic application of technology and process optimization underline the potential for these methods to be adapted and replicated across various business contexts, enhancing procurement efficiency and supporting broader organizational goals. s

Practical and theoretical implications

This research significantly contributes to reducing lead times and minimizing waste in procurement operations, which is particularly crucial for industries like agricultural machinery where timely procurement directly impacts production cycles. The study demonstrates that streamlined operations become more agile and responsive to market demands, promoting significant cost savings through strategies that reduce unnecessary delays and the number of activities within the procurement process. These savings result from decreased labor costs, owing to fewer personnel needed, and lower overhead costs associated with shorter cycle times. Moreover, the integration of digital tools such as e-procurement and blockchain enhances transparency and reliability in supplier relationships, accelerating the procurement process and improving the accuracy of supplier data. This leads to better decision-making and potentially more strategic supplier partnerships.

In a broader context, the research aligns with corporate sustainability goals by focusing on reducing waste and optimizing resource use, thereby lessening the environmental impact and fostering a more responsible supply chain. These practices not only support sustainability but also ensure that the company maintains a competitive edge in the market by enabling faster production times, superior product quality, and a swift response to supply chain disruptions or market changes.

The theoretical contributions of this study are also notable. It demonstrates how lean management principles and Industry 4.0 technologies can be integrated to foster operational efficiency and technological integration. This research provides a practical and tested model for digital transformation in procurement that can be theoretically analyzed and utilized as a benchmark in academic studies. It enriches curriculum development in academic programs focused on supply chain management, operational management, and business technology by bridging the gap between technology, management, and operational research.

Furthermore, the study contributes to understanding how changes in procurement processes affect stakeholder behavior, including adaptation and resistance to change. These insights are invaluable for developing theories related to change management and organizational behavior. Overall, the findings from this research can inform policy and strategy at both corporate and governmental levels, providing a foundation for developing guidelines and best practices for implementing digital tools in procurement processes.

Limitations and future directions

The findings from this research, primarily derived from the agricultural machinery sector in Thailand, highlight the limited generalizability to industries with differing operational dynamics and supply chain complexities. The economic, cultural, and regulatory contexts specific to Thailand may also affect the

applicability of the results in other geographical areas with distinct market conditions and business practices. This limitation is further emphasized by the focus on a specific sample of medium-sized engine manufacturers, suggesting that future research could expand the sample to include small and large enterprises to validate the findings across various business scales.

Future research should explore the applicability of these findings across different industries to validate and potentially modify the proposed procurement strategies to suit varying operational requirements and market conditions. Conducting similar studies in various global regions could provide insights into how cultural, economic, and regulatory differences impact the effectiveness of lean management and Industry 4.0 technologies in procurement processes. Long-term studies are also suggested to assess the sustainability of improvements gained through the implementation of digital and lean strategies in procurement, helping to understand the enduring impacts of such transformations.

Incorporating more qualitative methods could yield deeper insights into the behavioral and organizational changes accompanying new procurement processes. As digital technologies continue to evolve, ongoing research is necessary to keep pace with new developments and their implications for procurement practices. This includes exploring emerging technologies like AI and machine learning for predictive analytics in procurement, which could significantly enhance the efficiency and effectiveness of procurement strategies in diverse industries.

CONCLUSION

The development of robust improvement strategies, optimizing the purchasing operations and significantly reducing waste enhanced the overall operational efficiency and effectiveness of the procurement function, setting a precedent for the broader application of lean management principles and digital technologies across other sectors of the company. The study successfully demonstrated how procurement processes could reduce lead times from 342.49 minutes per order to 280.69 minutes, thereby saving 518 minutes per day. This was achieved by focusing on eliminating waste and streamlining processes. By integrating Lean principles and ECRS strategies, the study managed to simplify procurement steps and eliminate unnecessary delays, such as the protracted approval processes that had been slow and repetitive due to numerous approvers and lengthy approval times. This study not only underscores the direct benefits of applying Lean concepts to enhance purchasing efficiency but also highlights the potential for replicating these strategies to further optimize business operations across the board.

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