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Application of AI in Strategic Sourcing for Petrochemical Raw Materials

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## **Introduction:**

Strategic sourcing is particularly applicable in the petrochemical industry, as all expenses incurred depend entirely on the price of the raw materials: crude oil, natural gas, ethylene, and propylene. Purchasing these essential materials also exposes the industry to numerous challenges in sourcing materials due to the volatile nature of the pricing structure, unstable demand, and the need to rely on a global network of suppliers. Such difficulties are usually challenging when using conventional sourcing practices, particularly in a volatile and risky environment. The actions of procurement teams are primarily performed based on manual procedures, previous intelligence, and intuition, which can lead to inefficiencies, mistakes, and unnecessary expenses. A highly niche supply chain management requires a competitive and creative strategy to help it stay up-to-date and functional. It is therefore essential to introduce more advanced data-based mechanisms to address these shortcomings.

Artificial intelligence (AI) is a technology with the potential to disrupt entire industries, and it has numerous applications in procurement and supply chain management across various aspects. Neupane (pg. 3) indicates that AI improvements in strategic sourcing are becoming increasingly applicable, as they utilize algorithms and data-driven knowledge to streamline operations. The skills that AI provides in the fields of machine learning, predictive analytics, and automation help organizations make more informed decisions. The technologies have helped support complex tasks such as demand planning, price forecasting, and supplier risk calculation. AIs are brilliant with features that allow access to a mammoth amount of data in real-time. Additionally, they can incorporate predictive models that help sourcing teams improve their preparation by selecting suppliers more effectively, managing price fluctuations, and mitigating risks associated with delivery and geopolitical shocks.

Nonetheless, alongside these suggested advantages, the petrochemical sector relies heavily on more traditional sourcing tools, which often fail to address the complexity of modern supply chains. Procurements driven by human beings and narrow forecasting models are associated with errors and wastage. Such reliance on outdated data, which cannot predict future trends, exposes them to the risk of excess or deficiency of raw materials in both instances, resulting in additional expenses. Furthermore, the industry lacks a coordinated risk management solution, and as a result, it is vulnerable to supply chain disruptions, which can significantly impact scheduling and production costs. All these problems could be addressed with the help of AI, as once it is introduced, companies can apply predictive analytics, optimize trading decisions, and increase the efficiency of procurement processes. Automation will reduce manual work and errors and increase correct forecasting.

This article explores the potential applications of AI in strategic sourcing within the petrochemical industry, with a focus on price forecasting, supplier selection, and risk management. Examining the potential of AI as a powerful component of sourcing strategies, this work will analyze the possibilities of using AI-based applications to streamline sourcing strategies, making the most effective and cost-efficient decisions to purchase raw materials and reduce the risks inherent in this sourcing process. In its conclusions, the report aims to offer practical interpretations of the implementation efforts of AI technologies. It provides a summary on how to incorporate these tools into existing forms of procurement. This paper aims to determine that AI will be one of the key enablers of sourcing process changes in the petrochemical industry, leading to more efficient, cost-effective, and resilient supply chains. The paper argues that AI can revolutionize the sourcing operation through increased accuracy in forecasting, reduced procurement costs, and decreased risk in supply chains.

**Research Problem:**

Inefficiencies in the current sourcing processes used by the petrochemical industry have hindered the development of effective procurement strategies. These methods tend to be associated with complex negotiations, reliance on historic information, and dislocation with the rest of the global supply chains, which is unbearably hard. Lee et al. (pg. 101443) highlight that these standard approaches are wrong, particularly in dealing with price volatility and operational demand fluctuations in raw materials. The sourcing decision can result in overstocking and stockouts, as limited past data are taken into consideration or intuition is relied upon, which can be very counterproductive to the smooth operation of petrochemical companies. Overstocks increase the costs associated with storage and capital tie-up and reduce business opportunities since stockouts caused by overstocking interrupt production. Furthermore, the traditional methodology's inability to respond promptly to market-related changes implies that the time frame between the detection of problem occurrence and intervention to prevent it can be lengthy, contributing significantly to the problem's broadening. The inefficiencies thus harm profitable productivity and industry stability, making it evident that a more responsive, adaptive, and accurate approach is needed in the sourcing process.

Another significant problem with traditional sourcing is the uncertainty in demand and supply in the petrochemical industry. The cost of raw materials can fluctuate due to unpredictable market conditions, as well as geopolitical tensions, natural disasters, and global demand. Uncertainty also burdens the teams that need to stabilize their purchases by planning and getting the raw materials at desirable prices (Mohammadi et al., pg. 10). Being able to misforecast the demand may result in purchasing decisions that are either too large or too small, and that alone constitutes an inventory and operational nightmare. AI solves these problems through

predictive analytics, which helps to predict demand and supply. To develop more reliable forecasts, one can consider a substantial amount of available data from various sources, including market structure, historical data, and external factors that inform existing forecasts based on the paradigm of AI technology. This will enable purchasing departments to make effective and informed decisions using data, reducing the likelihood of overstocking and understocking. AI in sourcing can help companies develop their purchasing strategies and enable business organizations to be more effective, anticipating and responding to market fluctuations. In addition, AI devices can enhance decisions by considering multiple variables and provide a level of accuracy and insight that was previously unattainable using older methods.

Challenges in navigating the global supply chains also counter traditional sourcing issues. The chain of vendors in different areas faces threats and challenges unique to the region, which petrochemical organizations utilize. According to Vlachos and Reddy (pg. 24), such disintegrated and scattered supply chains might be complicated to orchestrate and respond to in the face of geopolitical hazards, economic fluctuations, and natural disasters. Such disturbances could have disastrous consequences by affecting sourcing schedules, prices, and the supply of raw materials. These dynamic scenarios are poorly aligned with conventional sourcing practices, which could lead to costly delays, price increases, and disruptions in supply chain logistics. AI tools, however, will make sense of potential risks in real-time, allowing procurement teams to anticipate potential upheavals and adjust their sourcing strategies accordingly. The systems with AI potential would analyze global events, trade directions, and market behavior, offering predictive power that would enable companies to be proactive rather than reactive. AI can enhance risk management and increase the visibility of the supply chain, allowing companies to

be better prepared to meet global challenges, less vulnerable to disruptive events, and, consequently, achieve greater supply chain resilience.

Most of the existing inefficiencies in the petrochemical business would be addressed if AI were used in strategic sourcing. Organizations have shifted towards a decision-making process that is more informed than human-only, utilizing AI in the procurement process to ensure greater input in data-driven decision-making. AI can assist the procurement team in more accurately estimating demand, predicting price fluctuations, and identifying potential activities that could compromise the supply chain. This would help shift towards data-driven decisions, where the accuracy of sourcing plans is enhanced, enabling organizations to save on expenditures related to excessive or insufficient stocks and lost purchasing opportunities. Additionally, with the aid of AI technologies, global supply chain visibility will enable it to face risks better and assess suppliers more effectively. As a result, applying AI to sourcing may lead to significant operational efficiency growth, procurement cost reduction, and overall profitability improvements for petrochemical corporations. Through AI, organizations will achieve greater stability in their supply chains, thereby making them better equipped to address the challenges of complexity and uncertainty in the petrochemical business.

### **Research Importance:**

AI has established a foothold in strategic sourcing, transforming procurement systems with its advanced technology, particularly reinforcement learning. As an example of the potential of reinforcement learning, Lee et al. (p. 101443) explain that it can optimize procurement processes in real-time, based on available market data, enabling predictive models that extrapolate prices and anticipate supply chain shocks. Organizations can use such machine

learning models to purchase their raw materials automatically and, in doing so, make sure that their buying strategy is in the best interest of the raw material market without attracting sampling of raw materials or under-purposing raw material supplies. Reinforcement learning is a process that changes based on past experiences of actions taken; hence, source strategies can also be optimized continuously. AI can also help determine when to purchase, ensuring that variable raw material prices do not influence the prices of petrochemical companies, and easily predict price fluctuations.

The impacts of using AI in strategic sourcing are long-term, enhancing several key factors of the procurement profession in the petrochemical sector. Among the most significant benefits, one can note the improvement in supplier selection, as AI implementations can review various supplier performance indicators, including delivery rate, reliability, and cost-effectiveness. This would ensure that companies choose suppliers who align with their strategic objectives, reduce risks, and stabilize the supply chain. Mohammadi et al. (pg. 12) observe that predictive analytics is instrumental to forecasting the oscillation in the supply and demand of raw materials. AI enables accurate demand predictions, optimal inventory balance, and timely ordering of materials when procurement teams arrive at the right time. Moreover, AI-related projects offset the cost-saving benefits by minimizing overstock and stockout risks, which is of superior importance in the petrochemical industry, where price fluctuations can be extreme.

The use of AI in strategic sourcing is a general paradigm shift in the petrochemical industry. As soon as AI technologies go live, companies can abandon traditional, standardized sourcing strategies and adopt more dynamic, data-intensive approaches that support end-to-end efficiencies and drive resilience. The AI will enable petrochemical companies to gain a competitive edge, as their procurement processes, demand forecasting, and supplier assessment

can be automated. This allows companies to respond to market introductions and changes within the shortest possible timeframe, maintaining their position at the forefront of the industry.

Furthermore, the AI-facilitated practices underline the more sustainable practice of enhanced waste, resource, and environmental management in providing raw materials. Finally, with the advent of AI, the petrochemical industry is poised to remain on a long-lasting winning track, thanks to its operational excellence and the development of its competitive advantage in a more dynamic global environment.

### **Research Objectives:**

#### *Primary Objective:*

To explore how AI can best coordinate the strategic sourcing of petrochemical raw materials to enhance procurement performance, cost effectiveness, and supply chain stability.

#### *Secondary Objectives:*

- To analyze the AI-based demand forecasting methods and their impact on accuracy in sourcing.
- To examine the AI-based models of supplier assessment and risk activities.
- To evaluate how AI can help cut procurement costs due to an improved ability to predict the price and optimally buy into it, as observed in Lee et al. (pg. 101443).

### **Research Questions:**

#### *Main Research Question:*

- How can AI be leveraged to optimize the strategic sourcing of petrochemical raw materials?

*Sub-questions:*

- What AI techniques can improve demand forecasting and pricing accuracy in the petrochemical industry?
- How can AI help evaluate and select suppliers, particularly in managing risks associated with price volatility?
- What challenges does the petrochemical industry face in adopting AI for sourcing, and how can these be mitigated?

**Research Hypothesis:**

*Main Hypothesis (H1):*

- The application of AI in strategic sourcing significantly improves efficiency, reduces procurement costs, and minimizes risks in sourcing raw petrochemical materials.

*Supporting Hypotheses:*

- Ho1: AI-based demand forecasting models will lead to more accurate procurement decisions, reducing excess inventory and stockouts.
- Ho2: AI algorithms for supplier selection will reduce risks associated with price volatility and supplier reliability.
- Ho3: Implementing AI in procurement will lead to measurable cost reductions and enhanced supply chain performance.

### **Previous Studies:**

AI is a force that has gained traction over the last few years in transforming supply chain management, particularly in the procurement sector. Strategic sourcing literature has also evolved over the years. There has been a discourse on how AI can help more strategically enhance the decision-making process, improve supplier management, and mitigate risk in acquiring raw materials. Neupane (p. 23) examines the role of AI in transforming strategic sourcing. The study demonstrates the automation of key procurement procedures, including supplier selection and contract negotiation, utilizing AI systems based on machine learning algorithms that enable the system to make data-driven decisions. Supplier evaluation with AI may also undergo a radical overhaul, as procurement teams can utilize predictions in analytics to validate factors such as supplier reliability, quality, and even prices. This predictive capacity of supplier performance streamlines the procurement process. It makes the process more cost-effective because companies no longer need to contend with the inefficiencies and costly mistakes that typically occur with such a manual decision-making process. Moreover, incorporating AI-enabled instruments contributes to more effective management of procurement risks, particularly in forecasting supply chain disruptions, such as refusal to increase prices or geopolitical risks that may significantly impact the procurement strategy. These are consistent with a shift in established procurement reporting and decision making, which was often based on prior relationships and less knowledge-based quantifications, to a more dynamic and responsive approach.

The other major field where AI is making a significant impact is demand prediction. Mohammadi et al. (p. 11) explain that the use of AI, specifically predictive analytics, can enhance demand forecasting in the petrochemical industry. Machine learning algorithms are

employed in predictive analytics, where companies can utilize large quantities of historical data to capture future raw material demand. In the petrochemical industry, where fluctuations in raw material prices can be significant due to market volatility, AI can help businesses better estimate and update their price change strategy at the procurement level. Effectively integrated with AI and aided by an AI-driven demand forecasting process, companies can prevent the risks of overstocking or underselling, streamline their inventory management, and minimize operational disruptions.

The approach can also help businesses establish a closer connection between their procurement plans and market trends, thereby positioning them better to proactively address supply chain shocks and disruptions at an earlier stage. AI can make demand forecasts more accurate and provide valuable insights that procurement managers can use to optimize their purchasing, ensuring that raw materials are available at the best price.

In the petrochemical industry, the application of AI is no longer confined to basic procurement tactics but rather to building practices that directly address the challenges of raw material sourcing. The paper authors (Lee et al., p. 101443) discuss the topic of AI, specifically reinforcement learning and perception, in the context of price prediction and procurement in the production of petrochemicals. Machine learning is a field that was created to tackle these issues, and one approach in this field, reinforcement learning, can be used to build AI systems that make decisions based on their experience acquired over time and in dynamic situations where the market is subject to frequent change, such as the sourcing of raw materials. Raw materials prices in the petrochemical sector are highly volatile and susceptible to various external factors, including geopolitical events, natural disasters, and fluctuations in international demand. Firms can also construct AI systems based on reinforcement learning to better predict future price

movements and make informed procurement decisions based on these forecasts. Such a system would enable companies to avoid under- or overpaying for materials, maximize the benefits obtained, and ensure better financial results. The more ambitious ambitions of AI to change procurement strategies through the inclusion of real-time market data, customer/product forecasts, and dynamically calculated decisions in sourcing are also mentioned in the work.

Vlachos and Reddy (p. 5) suggest a systematic review of machine learning algorithms in supply chain management, clarifying how these algorithms can support procurement processes more effectively. The concept of Machine learning has transformed itself into an efficient tool for optimizing demand and supply estimation, assisting companies in managing issues such as stockouts and overstocking. Machine learning is expected to enable more accurate prediction of the quantity of raw material needed in the future, which is crucial in industries such as petrochemicals, where the production cost of raw materials can comprise a significant portion of the overall production cost. Machine learning models can process substantial amounts of data, including historical consumption patterns, supplier performance, and market dynamics, enabling businesses to obtain more accurate forecasts and informed business decision-making guidelines. By improving the accuracy of demand prediction, machine learning can help achieve optimal inventory levels, reduce procurement costs, and provide greater predictability of raw material supply. The importance of machine learning in increasing forecasting accuracy cannot be overstated. Yet, the paper also highlights that the overall approach to sourcing can be optimized by integrating predictive analytics into all stages of the sourcing cycle.

Although the literature on the use of AI in the context of supply chain management is maturing, research on the specific application of AI in the strategic sourcing of petrochemical raw materials is lacking. Despite the substantial body of research on AI as applied to supply

chain and procurement optimization, little has been explicitly applied to the issues suffered by the petrochemical industry. Raw material suppliers face complexities such as price fluctuations, supply chain disruptions, and the need for long-term cooperation with suppliers. This requires a particular AI-based application, going beyond pharmaceutical systemization. The proposed study aims to address this gap by analyzing how AI can be applied to optimize the strategic sourcing of petrochemical raw materials, providing new insights into incorporating AI-centered decision-making experiences that are specifically applicable to this industry. The study aims to provide a detailed understanding of how AI can enhance the performance, cost management, and overall management of supplier relations within the petrochemical sector, ultimately creating a more nimble and cost-efficient supply chain.

### **Theoretical Foundations of the Study:**

Incorporating the increased presence and utilization of AI in strategic sourcing and efficiency optimization, it is essential to anchor the discourse in existing theories, which can help understand the importance of AI, its activation, and adaptation to the broader realm of strategic sourcing practices. The Resource-Based View (RBV) is one of the prominent theories that can be used to comprehend the role of AI in the procurement processes. According to the RBV theory, utilizing a competitive advantage can involve leveraging the firm's internal resources, proprietary technologies, information, and knowledge. When treated as an in-house benefit, AI can change procurement. Enterprises can enhance their supply chain competitiveness by leveraging AI technologies, including demand forecasting and supplier relationship management. Actionable intelligence obtained through the rapidity of AI algorithms has the potential to dramatically reduce the time it takes to make decisions by processing vast quantities of information in real-

time. For example, machine learning can provide more accurate demand forecasting. Consequently, procurement teams could buy raw materials more closely, translating actual consumption trends to prevent general waste and overstocking. Additionally, AI tools, such as predictive analytics, can help businesses identify trends in supplier performance or price trends, enabling them to make more informed decisions about supplier selection and negotiation. AI, in this instance, can be likened to a high-tech in-house tool directly involved in the strategic sourcing process, streamlining it and making it more cost-effective.

The second critical theory is the Theory of Transaction Cost Economics (TCE), which examines the costs associated with transactions within an economy, both within a firm and between firms. TCE asserts that the objective of firms is to minimize transaction costs, including the costs associated with searching for suppliers, negotiation, and performance evaluation. The high transaction costs are evident in the slow decision-making and lack of data analytics in many traditional procurement processes. AI can significantly reduce such costs by automating procurement processes. An example is AI algorithms that automate the search and selection of suppliers using large amounts of data on their performance, reliability, and other relevant factors. The AI-enabled automation systems minimize decision-making errors and reduce the time spent on administrative tasks. Moreover, AI solutions need to automate negotiations with suppliers, utilizing their historical records to determine the most favorable rates and market conditions, so that companies can negotiate more advantageous terms with minimal effort required. The applicability of TCE to AI in sourcing can be further substantiated with the help of Neupane (pg. 33), who elaborates that AI-based tools (machine learning and natural language processing) can significantly reduce transaction costs by streamlining the speed of supplier-binding efforts and improving decision efficiency.

Another theory that can be applied to AI is the Predictive Analytics Theory, which posits that future trends and behaviors can be predicted by analyzing and utilizing large datasets. In strategic sourcing aspects, AI has been able to forecast demand, predict price fluctuations in raw materials, and assess supplier reliability using predictive analytics. By analyzing past trends in a supply chain with a high accuracy rate, machine learning models can extrapolate future supply chain trends, enabling procurement managers to make proactive choices rather than responding to changes. As discussed by Mohammadi et al. (p. 8), predictive analytics through AI can help petrochemical companies forecast changes in demand for raw materials, along with their corresponding prices, leading to more effective and cost-efficient procurement. This feature lowers the danger of rationing or oversupply. It amplifies the financial planning and risk management roles, especially when demand forecasts and price fluctuations are among the critical operations.

Additionally, in an AI-driven decision-making environment, Reinforcement Learning (RL) can be applied, particularly in dynamic settings such as purchasing and costing. In particular, Lee et al. (p. 101443) highlights how reinforcement learning can enhance decisions in the face of permanent change and uncertainty, which are common in the raw materials market. Built on the ability of the AI system to learn over time and gradually adjust its response to new situations, RL will enhance the quality of sourcing decision-making in the long term. In procurement, RL could be used to manage pricing schemes, where the system would gradually learn about past price variations, supplier dynamics, and optimize the pricing approach, i.e., how and when to make purchases to minimize costs. Such a learning process renders RL especially helpful in versatile and dynamic supply chain systems, where traditional models often fail to track the rapid changes that occur.

In addition to these theories, additional analysis will include a thorough Theoretical Framework to determine how AI can be implemented in strategic sourcing. It will also use machine learning to estimate purchases, predictive analytics, and reinforcement learning to assist in selecting suppliers and maximizing prices. Integrating AI methods will provide several insights into how to streamline the purchasing decision process, including setting proper expectations for demand and pricing dynamics in the future, minimizing risks in supply chain aspects, and facilitating more effective negotiations with suppliers. The study will benefit this theoretical perspective by providing evidence that AI can implement strategic sourcing practices in the petrochemical business, demonstrating how AI-enabled technologies can facilitate procurement processes with cost and risk reduction in a highly globalized and competitive world.

### **Methodology:**

The study will employ a mixed-methods approach, which combines qualitative and quantitative methods. The results of AI in the strategic sourcing of petrochemical raw materials can be obtained with the help of a mixed-methods design, which would provide a clear picture of all the available results. Interviewing will serve as the basis of the qualitative study among the procurement managers in the petrochemical industry and the supply chain professionals and staff in the AI sector. This line of interviews will provide an insight into the practical specifics, experience, and prospects of utilizing AI tools in sourcing operations. Such growth in practical experience among these professionals will contribute to identifying barriers to AI integration, including technical limitations, organizational resistance, and knowledge gaps regarding the use of AI.

Furthermore, they will provide feedback on how AI can be improved and utilized to develop more effective procurement strategies in the petrochemical industry. Surveys will be preferred in the quantitative part to collect data that helps quantify the impact of AI on the following procurement performance metrics and indicators: efficiency, cost reduction, and supplier relationship management. The mixed-methods research design will enable the triangulation of qualitative and quantitative data, providing detailed information on the potential of AI in petrochemical raw material strategic sourcing. The qualitative findings will be combined to assist in contextualizing the statistical findings, enhancing the interpretation and utilization of the research findings.

### **Sampling:**

Using this study, the target population will encompass the public of procurement managers, supply chain specialists, and AI specialists in the petrochemical industry. Procurement managers are at the core of the sourcing process—they decide and build relationships with suppliers. Supply chain professionals, including logistics and inventory managers, will also be included in the sample, as these individuals directly impact the success and efficiency of sourcing efforts. AI experience within companies that already use or are considering using AI in their procurement will also provide technical knowledge of the operation and functionality of AI tools. Stratified random sampling will ensure that a comprehensive and representative sample is realized. To solve this, stratified sampling divides the population into separate subgroups (e.g., companies of diverse sizes, regions, and varying degrees of AI implementation) to ensure that each subgroup has equal representation. The sampling will encompass a diverse range of small and medium-sized enterprises (SMEs) as well as large, multinational petrochemical companies.

This will enable the research results to be generalized to other sizes of organizations and levels of technological maturity. The sampling procedure will also rely on geographical diversity, including companies located in regions with varying rates of AI implementation and technological infrastructure.

### **Data Collection:**

In this research, semi-structured interviews and surveys will be the primary methods of data collection. The questionnaires will be distributed among the target audience through procurement managers, supply chain professionals, and AI specialists. The questionnaires will be anchored around the contribution of AI to the success of procurement effectiveness, cost reduction, supplier management, and the strategic overview of the overall sourcing performance. Specifically, survey questions will ask about the effect of AI tools on the decision-making process, the speed of contract choices, their accuracy, and the extent to which AI tools have contributed to prioritizing costs and mitigating risks. The interviews will provide quantifiable information that can be applied to measure the relationship between the adoption of AI and procurement performance measures.

Semi-structured interviews with experts will be conducted, along with surveys and some qualitative data. The interviews will help to explore the opportunities and challenges of AI adoption in strategic sourcing more profoundly. The semi-structured interviews will be anchored on predetermined questions. Still, they will be fluid enough to permit the interviewees to provide more details and share experiences that would have been beyond the scope of the questionnaires. The interviews will serve to understand the reality of AI in implementation, how it impacts people's decision-making process in the sourcing process, and what hinders the universal

application of AI. Interviewees will also discuss how an AI-based system can be expanded and share their perspectives on any organizational or technical issues that need to be addressed.

### **Data Analysis:**

Data analysis will be qualitative and quantitative to provide a detailed portrait of the impact AI is having on strategic sourcing. Using regression analysis, the quantitative data will be used to test the correlation between AI applications and other procurement performance metrics. Specifically, the regression model will examine the dependence between AI adoption and procurement efficiency, cost savings, and supplier management. By examining these variables, the paper will investigate whether AI has a statistically significant influence on these five areas of the sourcing process. To ensure that these factors do not confound the regression results, the analysis will also control for the size of a company, industry type, and geographical location.

Regarding the qualitative data, a thematic analysis would be performed to identify and explain the most significant themes, challenges, and best practices for integrating AI into sourcing processes. Thematic analysis: The thematic method will be employed to code the interview transcripts, and patterns or themes that can suggest the possible reasons for the broader AI adoption situation will be identified. Technological concerns such as compatibility with legacy systems, organizational barriers such as resistance to change, and the perceived value of AI (e.g., an improved decision-making process, a reduced cost of procurement items) may be included in such themes. The above critique will highlight the instances in which AI can be effectively implemented and the challenges that must be addressed to ensure the implementation fulfills its potential. Combining regression and thematic analysis will provide a comprehensive

and detailed snapshot of the impact of AI on strategic sourcing in the petrochemical industry, along with the opportunities and challenges of researching and implementing it in the future.

### **Research Tools:**

AI tools are also critical in helping procurement practitioners maximize procurement processes in petrochemical raw material strategic sourcing activities, such as demand forecasting, price forecasting, and supplier identification. One will create demand forecasting models based on machine learning platforms, i.e., TensorFlow and Keras. The platforms also enable the design of complex machine learning algorithms to analyze past data, identify patterns, and predict trends in raw material demands, allowing companies to anticipate market changes more effectively. Furthermore, IBM Watson and SAP Integrated Business Planning (IBP) will be used to take advanced predictive analytics and supply chain optimization. IBM Watson AI-based business insights will help identify supplier risks, optimize inventory, and mitigate price volatility. In the meantime, SAP IBP integrates AI with real-time data to optimize demand and supply planning activities. It provides essential insights to the procurement department, enabling them to obtain cost-efficient raw materials and manage costs effectively.

### *Data Analytics Tools:*

Raw data cannot be converted into practical knowledge without a process component. Two of the primary data processing tools used during statistical analysis and data manipulation are R and Python. Python offers comprehensive facilities for handling both large and small datasets, cleaning data, and training machine learning models using libraries such as Pandas, NumPy, and Scikit-learn. It supports various data analysis tools, such as regression analysis, clustering, and classification, which could make it valuable concerning AI use in SCM. R is

superior, however, due to its broad spectrum of statistical analyses and the ability to produce visually appealing data graphics. Packages that analyze and provide data exploration, such as ggplot2 and dplyr, allow researchers to detect trends and formulate worthy estimates when sourcing raw materials.

#### *Optimization Tools:*

Resourcing is also essential in strategic sourcing, particularly in achieving the optimal balance between procurement spending, suppliers' performance, and inventory levels. These include the likes of Gurobi and CPLEX, which are designed to tackle complex optimization issues, such as determining the optimal order of providers or the most economical means of acquiring materials, while incorporating machine learning models. This software involves extensive mathematical optimization, utilizing linear and integer programming to resolve the sourcing dilemma. By analyzing massive amounts of data and optimizing decision variables, these tools enable companies to minimize procurement costs and enhance supply chain efficiency. Other packages, such as Python and R, may also be used in conjunction with Gurobi and CPLEX, allowing data analysis to be directly integrated with optimization in procurement.

#### *Visualization Tools:*

It is crucial to present processed and analyzed data in a clear, concise, and accessible manner. Analytical tools like Tableau and Power BI can be helpful, as they enable stakeholders to visualize complex data and trends easily. Tableau enables interactive dashboards that display real-time supply chain KPIs, prices, and procurement efficiency. It can be instrumental in visualizing large datasets and generating comprehensive reports that support informed decision-making. Developed by Microsoft, Power BI offers a similar tool that enables users to connect to multiple data sources and create reports and dashboards tailored to their business needs. These

visualization devices ensure the sufficiency of unveiling the results of AI-guided forecasting, optimization, and data analysis to all stakeholders within the organization.

### **Research Limitations:**

The main limitations of this study include the data, as petrochemical companies may not be willing to release data that could be proprietary or sensitive voluntarily. Due to confidentiality and competitive advantage, employers have always been cautious of their internal information concerning procurement, AI integration, and raw material costs. Due to such privacy concerns, Neupane (p. 65) discusses this issue by observing that it is difficult to obtain accurate and real-time evidence about the use of AI in strategic sourcing. Consequently, the study can rely on publicly available information, and the quality and timeliness of the research may not be as accurate.

The technological problem involved in the varying magnitude of AI uptake among firms is also a constraint. They cannot be used to generalize the results to all the petrochemical companies, which may not have adopted AI as discussed in this research. Emerging markets firms may lack access to advanced AI solutions and fail to integrate such technologies successfully into their purchasing behavior. Vlachos and Reddy (p. 28) suggest that the disparity in the distribution of AI across various industries can skew the results of any study regarding its economic value, as organizations with different technological maturity levels will have varying degrees of success implementing AI-based solutions. In turn, these findings may encapsulate the experience of more developed firms concerning AI and are not necessarily transferable across all firms within the industry.

Finally, the research's geographical scope might be limited. Given that the survey may be based in countries with higher AI utilization, such as North America, Europe, or East Asia, the findings may not be as relevant to companies where AI usage is less widespread. The situation in less AI-developed regions can present specific barriers to AI adoption in strategic sourcing, such as the absence of infrastructure and limited AI investments, as noted by Mohammadi et al. (p. 7). In this way, the results of the present study may not be exhaustive in describing the reality of AI adoption in all world markets.

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