Modernizing Procurement in Supply Chain with AI and Machine Learning Techniques

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Abstract

Public procurement in Europe represents, on average, 16.9% of the GDP and is the cornerstone of the European Single Market. Simplifying public procurement and reducing procurement administrative costs for the public and private sectors can deliver substantial benefits at the national and European levels. However, the complexity and diversity of public procurement processes, as well as the huge expenditure at hand, implement automatic systems tailored to specific procurement needs necessary. This paper shows how artificial intelligence, and in particular machine learning techniques, can be used to modernize public procurement. It presents implemented systems and showcases pilot projects. The results of an extensive evaluation are also reported.

The paper also argues that public procurement should be used more strategically by public administrations. This means aligning procurement actions with overall business objectives and using procurement to leverage supplier innovation and create a competitive advantage. Such advanced objectives are seldom achieved through the lowest price model. The paper also contains several recommendations for both the supply and demand sides to help realize the full potential of public procurement. On the supply side, recommendations relate to a better understanding of how artificial intelligence can be used in procurement activities, working with AI systems, and creating AI systems. On the demand side, recommendations involve the careful planning of how and when to use AI in procurement activities.

Keywords: Modernizing Procurement in Supply Chain, Industry 4.0, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), Smart Manufacturing (SM), Computer Science, Data Science, Vehicle, Vehicle Reliability
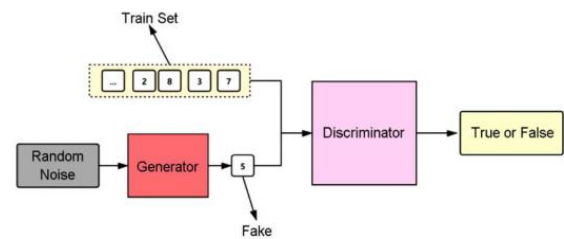
1. Introduction

Public spending is budgeted well in advance by governments in areas that include – among others – national defense, education, healthcare, transportation, and law enforcement. Procurement is the process through which these goods and services required to meet public needs are acquired, whether by a government or by separating institutions like public education, health, or administrative service facilities. Procurement is also a central function within the business supply chain, focused on acquiring the required goods and services on time, and with the appropriate quality payments. Procurement generally represents a considerable part of the running costs of government – and in the

business world as well. Unsurprisingly, many efforts are invested in trying to reduce the costs of procurement. The emergence of e-marketplaces and the increasing use of eAuctions are examples of how modern technology is employed to take cost out of the procurement process.

The area of procurement needs more attention. Using Artificial Intelligence (AI) techniques promises significant benefits. AI can help define more complex strategies to figure out the best process for tender and bidding in procurement. It can also optimize a great variety of activities related to managing the recurrent problems that

Fig 1.Learning model for supply management

pop up in every procurement cycle. Section 2 will discuss the part of government spending procurement represents. Section 3 will outline problems that frequently occur in government procurement. In Section 4, we will highlight how Artificial Intelligence and Machine Learning can help to alleviate these problems. In Section 5, we give concluding remarks.

Fig 2. Pharmaceutical supply chain and the main processes

1.1. Background

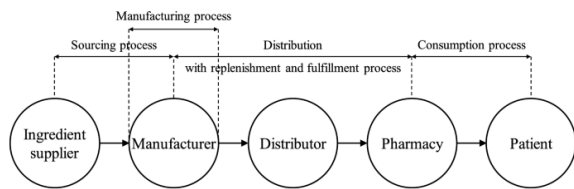Supply chain management (SCM) is the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. It represents a network of interconnected activities (including procurement, production, transportation, warehousing, distribution, and customer service). Among all these activities, procurement is one of the most important functions in every organization. It is the process of acquiring goods, services, or works from an external source. Procurement in business usually requires someone to buy supplies or services from an external source and is typically responsible for the flow of materials from the suppliers to the organization. Operating and maintaining an effective procurement process is vital since it can have a major impact on the organization's cost, performance, efficiency, and financial results. With product costs typically accounting for over 50 percent of the average company's cost of goods sold, procurement presents an opportunity for substantial savings. Be it direct or indirect spend, better procurement can result in better margins.

Traditionally, procurement functions mostly operate reactively. They issue purchase orders based on inputs such as requisitions from various departments within the organization. These purchase orders are sent to specific pre-approved suppliers, who in turn generate proposals and then fulfill the orders. This reactive way of functioning has, over time, cost procurement functions plenty. There is much research and development around transforming procurement functions from being largely reactive to becoming highly proactive. When a procurement function is proactive, it engages with potential suppliers in the market long before a specific need materializes for a product or service within the organization. In this way, the organization and the suppliers both benefit from early engagement as it allows time for discussions, negotiations, and re-equipment, if necessary. Early engagement can help to identify and select the best suppliers capable of fulfilling the organization's requirements regarding quality, timeliness, and cost.

1.2. Overview of AI and Machine Learning in Procurement

Artificial Intelligence (AI) technologies are quickly modernizing all departments of a business, and the procurement function of the supply chain is no exception. Supporting areas like accounts payable, e-sourcing, contract management, and others, with the help of AI abilities can produce surprising improvements. AI refers to simulated intelligence in machines that can perform and complete tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and language translations. AI is a way to conceptualize, build, and understand intelligent systems. These are systems that can perceive the environment and take actions that maximize their chance of successfully achieving goals. AI is composed of two aspects: the creation of intelligent systems and the study and examination of human intelligence. AI can be implemented in a variety of different ways and commonly refers to the use of a machine, especially a computer, to carry out the intelligent task of creating intelligent behavior in machines.

In the procurement space, AI can offer much assistance. To mention a few, it can help with the payment of vendors and your liabilities. It can also be used to manage the contracts that govern your purchases and relationships with the vendor. In addition, it is a powerful way to help manage services, goods, and rates for the betterment of the company. AI can also help manage the money spent on goods and services effectively. Furthermore, AI can be used in e-sourcing to find the best vendor for your product or service. Finally, AI can help send an intelligent purchase order and confirm intelligent delivery. With the increasing interest of industry and academic communities in AI technologies, leading enterprises can effectively apply AI technologies to modernize procurement actions and gain competitive advantages. Having an advanced procurement organization can result in obtaining lower costs of goods and services as well as stimulating innovation from the vendors.

Machine learning is a subsection of AI that revolves around the use of algorithms and statistical models that allow systems to perform a task without specific instructions by taking data (hence, learning from it) and making decisions or predictions based on that data. It is about developing systems, letting them learn from data, and eventually making decisions or predictions based on that learning or model. Much of machine learning is present in the creation of 'models'. These models are created for two reasons: the first is to explain data, and the second is to make predictions. Machine learning can be seen as a set of methods that can automatically detect patterns in the data. These patterns then allow the machine to make predictions and decisions. In summary, machine learning is a combination of techniques and methods that allow an AI system to make sense of the data, to act intelligently based on the data, and to improve the decisions it makes in the future.

Fig 3 :AI in the logistics industry

2. Challenges in Traditional Procurement

Traditional procurement processes are designed to ensure that an organization's buying activities are conducted fairly and transparently. However, these processes often stifle initiative and creativity on the part of both buyers and suppliers, resulting in suboptimal outcomes for all parties involved. Indeed, many of the most serious challenges in the procurement process stem from the application of overly prescriptive rules for determining what, when, and how to buy.

One of the key challenges in the procurement process is determining what to buy. Traditional

procurement processes begin with the identification of a need and the creation of a detailed specification of the required goods or services. This specification is then used to create a request for proposal or invitation to tender, which is sent to a select group of pre-qualified suppliers. The suppliers respond with proposals that are evaluated against the stated criteria, and a contract is awarded to the supplier that offers the best value for money. However, this approach assumes that the buyer knows best and that suppliers are essentially passive agents who will only offer innovative solutions if explicitly instructed to do so. In reality, many suppliers have a better understanding of the market and the buyer's needs than the buyer does and are willing to invest in developing new products and services that meet those needs if the buyer is willing to enter into a more collaborative relationship.

2.1. Manual Processes and Inefficiencies

Manual efforts in enterprise supply chain management are often redundant, unsatisfying, and detract time from value-added activities. A typical purchasing agent in the mid-1990s spent 40% of the job on administrative tasks, 40% on tactical tasks, and 20% on strategic tasks. Many of these administrative tasks could be eliminated, allowing agents to focus on more strategic activities. Enterprises are increasingly leveraging e-procurement applications to take cost out of the supply chain. Actionable tools from e-procurement vendors promise to reduce "maverick" buying, a key source of lost savings. While the promise of e-procurement software is real, the path to realizing value can be treacherous. Typical e-procurement projects suffer from poor adoption as users resist new processes that add layers of approvals and bureaucracy to existing tasks. In addition, current e-procurement approaches rely on vendor-controlled catalog content, which may not fully support an organization's purchasing requirements.

Today's supply chain procurement is fraught with challenges on various fronts. The existing manual purchase order processes involve multiple challenges such as handling paper-based purchase order processes and tracking approvals, variations, and denials on paper. Their difficulty in managing these manual purchase order processes often results in delays, errors, and losses for all participants. These challenges result in legal users bypassing the company's approved product/service lists, shipping and receiving products without appropriate approvals, and vendors shipping products without validation of the purchase order. As a consequence, enterprises suffer from a wide variety of interacting issues, such as excessive maverick buying, unapproved product/service purchasing, undercut contracts, and overloaded purchasing agents, as well as shipping and receiving products without purchase order approvals.
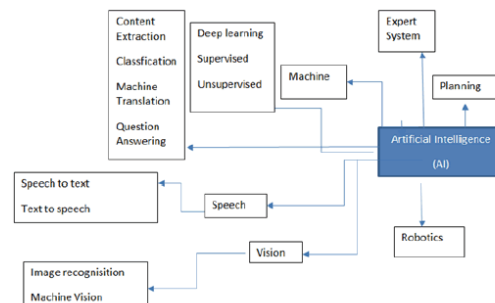
Fig 4: Different field AI is performing

2.2. Lack of Data-driven Decision Making

Decision-making in procurement is often pioneered by category managers and for a large part rooted in specialized knowledge for a very specific set of purchased goods or services. Whereas a lot of state-of-the-art technology, like robotics or artificial intelligence, is often perceived as threatening job creation, it is exactly the lack of data-driven decision-making that currently hampers broader and more ambitious procurement strategies. The biggest challenge to get started with bigger data and AI is the fact that the data is often not there where it is

produced and used. Consequently, a lot of data resides in silos, and disparate systems repositories, and never reaches the procurement or supply chain professional that needs it to make better decisions. It is estimated that Knowledge Workers spend approximately 50% of their time hunting for data and information, but then again procure only 2 hours per day manipulating documents and using other written data to make purchase order decisions or use it for negotiations with their suppliers.

These statements and percentages illustrate, on one hand, the amazing opportunity to improve procurement with AI techniques, but we cannot neglect, on the other hand, the hurdles of getting AI going as successful innovation in practice. The biggest hurdle is thus to get data from written procurement business artifacts, like purchase requisitions, purchase orders, supplier offers, or contracts. This kind of data is typically unstructured or semi-structured data from the perspective of classical IT systems. The unstructured data forms about 80% of the procurement data and is stored in heterogeneous sources, like Cloud repositories, supplier offers, email bodies or email attachments and other written artifacts. According to IBM, unstructured data is information that does not reside in a traditional database. Organizations use unstructured data for nearly 90% of all information that they work with, and this data originates in several forms: textual, emails, digital images, videos, audio files, web content, or social media content. It has been known for many years that unstructured data or content is much more difficult to manage and control, and more difficult to exploit

3. Benefits of AI and Machine Learning in Procurement

There are tremendous benefits to employing AI, machine learning, or any other modern technology in the procurement process. First of all, procurement can deliver more value. By freeing procurement professionals from the tedium of repetitive tasks, organizations can benefit from a

more strategic procurement function. Teams can concentrate on more complex activities such as building relationships with key suppliers or understanding and mitigating supply chain risk. Secondly, it enables smarter spending. AI-powered procurement systems can proactively direct employees toward preferred suppliers or negotiate contracts before a purchase is made. This not only ensures compliance but also helps organizations to get the best value for money.

Furthermore, it fosters innovation. When AI is employed to handle the transactional aspects of procurement, professionals are liberated to collaborate with suppliers in new ways and find innovative solutions to common issues. For instance, they can work with suppliers to ensure the continuity of supply, co-develop new products, or share forecasts to help suppliers plan their production more effectively. Finally, it creates better data. In an AI-powered procurement system, all data is connected and readily available. This means that the systems can provide users with a 360-degree view of supplier information, performance, and risk to help users make informed decisions. In addition, the centralized data can be used to generate insights and predictions which can be delivered to procurement professionals to add value..

## 3.1. Cost Reduction and Efficiency Improvements

Supply chain organizations focus on procurement to control costs and maximize the value created within each department. Modernizing procurement relies on combining centralized control with the ability to extract unique insights from different locations and parts of the organization. These unique insights can be made available through specialized AI applications, helping the staff at the coal face of procurement make the best decisions.

In the Infor Nexus network, buyers have centralized control over supplier onboarding and setting up preferred supplier lists. They also have full visibility

of all orders placed by their organization across the network. To help make the plethora of day-to-day buying decisions, buyers can implement AI applications that score and categorize suppliers, predict supplier performance, and perform supplier risk analysis. Buyers can also use AI to set up and manage supplier collaboration and to investigate any procurement-related issues using natural language understanding AI capabilities within their communications channel.

The AI models are trained using data that already exists within the network. This data is in the form of structured transactions, and also unstructured data that can be converted into structured data, with the necessary context provided by the procurement applications. This approach balances centralized data control with distributed application intelligence.
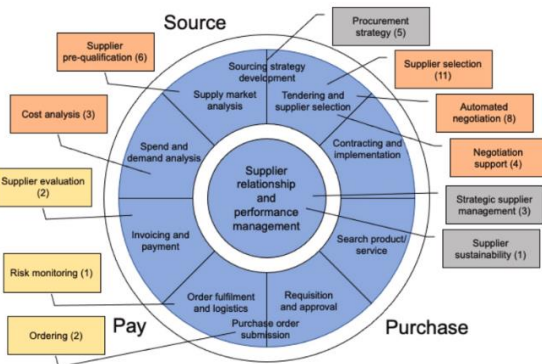
Fig 5: case cluster mapping

3.2. Improved Supplier Relationship Management
Supplier relationship management is key in procurement processes. Through effective supplier relationship management, organizations can gain a competitive advantage, reduce risk, increase market share, and gain access to wider expertise. Intelligent automation tools from various technology vendors

can help bring more visibility and control to this area. They can highlight potential risks and allow the buying organization to address them before they cause a problem. They can also identify upcoming opportunities for better collaboration resulting in mutual benefit.

For supplier discovery, intelligent tools can help scan the internet and external document repositories of suppliers, extracting critical information and presenting it to stakeholders. Blockchain addresses the perennial issue of trust, enabling secure information sharing, and collaboration, and providing audit trails. When applied to procurement, businesses get a unified view of transactions across the supply chain network.

Machine learning can help understand buying behavior for a particular category and supplier risks associated with it. It can predict the likelihood of risk or opportunity and drive different stakeholders to act in a coordinated manner to address it. Meanwhile, artificial intelligence and machine learning can drive the enhancement of the procurement process and its linkage to the industry and other business areas. They can identify synergies and guide the strategies involved, not only efficiently but also deeply, to be accurate in tactical and operational decision-making.

In conclusion, let's say that AI/ML is the glue that connects all sophisticated technologies and business improvement of procurement, making it no longer just a process but a crucial core for the survival and enhancement of the modern company, which thrives on its creativity and execution.

4. Integration with AWS IoT and Kafka Streams
In this section, we discuss different case studies and examples that help illustrate how artificial intelligence (AI) and machine learning (ML) are transforming procurement in supply chains. While not an exhaustive list, these examples help demonstrate the practical applications of AI and ML in addressing procurement challenges.

.The first case study details how a global telecommunications company utilized AI to automate the process of combining and validating purchase orders, goods receipts, and invoices. Through training ML models to recognize different document types, along with key data fields, the AI systems were able to help procurement departments streamline their processes and reduce the cycle time for projects. The second example comes from a supplier of optical networking hardware, where AI was used to forecast demand for more than 25,000 materials in 90 different plant locations. By leveraging a time-series neural network architecture, the company was able to significantly increase the accuracy of its demand forecasts. The third case study describes how a multinational oil and gas company utilized ML to assess and rank suppliers during the supplier selection process. By combining different ML methods into a hybrid approach, the company was able to increase the speed of the supplier evaluation process while also improving the quality of the final recommendations.

Overall, there is a great deal of potential for the continued use and development of AI and ML techniques to help resolve the many challenges within the procurement function. Furthermore, combining advanced technologies like robotics process automation (RPA) with AI and ML can help to create end-to-end automated solutions that vastly improve procurement processes. Given the increasing amounts of data available and the rise of cloud computing services, the next generation of AI and ML models will help enable proactive supplier management, and contract compliance, and will facilitate the development of conditional supply networks that are responsive to unexpected events

4.1.Successful Implementations in Industry
There are several examples of such kind in different industry settings. Measuring the success and progress derived by this type of procurement gains special importance. Developing a success model

using Machine Learning techniques is one way to accomplish this challenge. The results of a successful application can predict the chances of success of future projects, making the necessary adjustments. This paper considers several such criteria of success, alongside data regarding implemented e-procurement projects.

There are some stages of the procurement process that are best suited for automation or the application of Machine Learning and AI. The stages include listing purchased goods and services and available suppliers; receiving responses or proposals from suppliers, such as price, availability, delivery, and quality proposals; negotiations of proposals with one or more suppliers, including prices and conditions; making purchase orders, monitoring delivery, and receiving goods; and reconciliation of invoices, matching them with purchase orders and goods received, and approval for payment. Note that several of these stages are pivotal for the success of the procurement, due to their risk and/or impact nature, often represented as risk events in Enterprise Risk Management (ERM) frameworks.
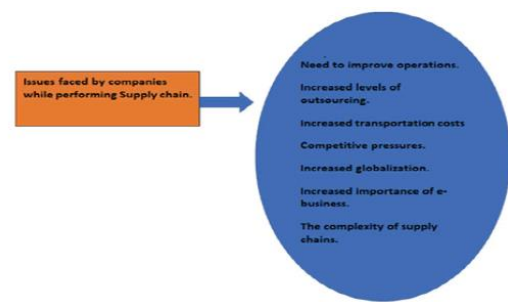
FIGURE 5: Supply chain management production.

5. Future Trends and Opportunities
The study of the procurement function within the supply chain has gradually gained attention with the realization of the significant impact it has on achieving competitive advantage. However, the development of models and tools that reflect the real challenges and opportunities present in the

procurement environment has not advanced to the same degree. This has created substantial gaps in researching and understanding how to solve operational as well as strategic procurement problems. In this chapter, we present several future opportunities and trends within the procurement function. We start by emphasizing the potential benefits that could be obtained from interlinking market and procurement dynamics. Then we proceed with several unique industry settings with associated specific challenges, which have not been widely identified in the current literature. Finally, we conclude with the emerging trends and the new way solutions are being developed and implemented.

The development in e-commerce business-to-business markets offers the opportunity to link demand forecasting systems with dynamic market information and proposes several research directions in the area of linking market information to enterprise systems. Many of the presented concepts and research directions can also be applied to the procurement function, particularly when considering both the buy and sell market dynamics together. The integration of both aspects can lead to the development of more advanced models and systems that can support the decision-making process in both procurement and sales for a better overall supply chain performance. Furthermore, organizations with large and complex procurement processes are likely to benefit from using AI and Machine Learning techniques in automating such processes, reducing operating costs as well as implementing procurement policies that lead to a better flow of products and services from the suppliers.

5.1. Potential Areas for Further Innovation

There are several potential areas for further innovation. First, public procurers can further nurture innovation in potentially high-impact areas, such as green technology, robotics, autonomous driving, cybersecurity, and smart materials. Second,

public buyers can take advantage of innovation support measures when available to effectively plan ICT- and non-ICT-related advanced or pre-commercial procurements or procurements requiring a solution of a high degree of complexity, novelty, or risk. Third, public procurers can increase recruits AI's help in performing highly granular analyses of contracts and their terms and conditions to prevent disputes and discrepancies, as well as potential corruption cases. This would also help to avoid the failure of future contracts. Such analyses are now performed by legal professionals but could be supported and sped up by dedicated AI systems that have not been developed and deployed to date.

Efficient and effective public procurement is the backbone of good governance. It ensures that the public sector spends the citizens' hard-earned money transparently at the least possible cost for needed goods and services of the right quality, coming at the right time, and provided by legitimate suppliers. AI and machine learning techniques have the potential to modernize publicly driven supply chains, mostly by increasing the efficiency of these public procurements, reducing the risk of corruption for public officials and private bidders, and helping in overseeing compliance with the awarded public contracts.

6. Conclusion

In today's evolving and digital business landscape, the procurement function is transitioning from a transactional role to a strategic and collaborative entity. It is integrating with other areas of the business, such as finance, operations, and supply chain, and applying advanced technologies to create efficiencies and add value. At the same time, external forces are pressuring companies to take action in CSR and sustainability. Leading outsourcing and consulting firms are at the forefront of these changes, offering innovative solutions and services to help companies evolve their procurement functions. By collaborating with these firms, enterprises can realize new levels of

performance and deliver improved business outcomes.

A growing area of opportunity is the use of emerging technologies, such as AI and machine learning. Today, companies are using these technologies to modernize procurement. They are automating manual processes, gaining real-time insights from data, and applying advanced techniques to enhance decision-making. By doing so, enterprises are accelerating their procurement performance and transforming their supply chains. However, there is still a long road ahead. Many companies are in the early stages of their AI journey and are experiencing barriers to adoption. Sourcing and procurement leaders must learn from early adopters, understand the current state, and take action to move forward.

6.1 Future Trends

The first trend is the increasing interest and the large use of electronic commerce techniques in the procurement area. E-purchasing is gaining a huge interest not only in public procurement but in the private sector due to the many large tangible and intangible benefits encapsulated in the e-procurement process. Another key trend over the next few years is that organizations will focus on spending more effectively. Inefficiencies in spending have very direct, negative effects, but companies often struggle to address problems. The third trend is a growing realization by organizations that real strategic leverage can be gained in procurement, particularly in the areas of market intelligence for bidding and negotiations.

Another aspect likely to characterize the evolution of the procurement function is the growing inclination to outsource important parts of the procurement activities to specialized professional firms that guarantee the achievement of results and establish sharing mechanisms based on the savings guaranteed. Firms typically do not have the same breadth of experience or the same deep knowledge of specialized categories of goods and services as the market leaders. Lastly, there will be a growing

adoption of new technologies like data mining, machine learning, and artificial intelligence to support the decision-making process of the procurement function.

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