EXPLORING NEW TECHNOLOGIES IN PROCUREMENT

Abderahman Rejeb [1], Edit Sűle [2], John G. Keogh [3]

[1] *Széchenyi István University, Department of Logistics and Forwarding*
Egyetem tér 1, 9026 Győr, Hungary,0036702485605, e-mail:abderrahmen.rejeb@gmail.com
[2] *Széchenyi István University, Department of Logistics and Forwarding*
email:suleedit@gmail.com
[3]*University of Reading, Henley Business School, UK, email: john@shantalla.org*

Abstract:
Rapid advancements in digitalization are reshaping global supply chains and transforming the current modus operandi of the procurement function within companies. Broadly, procurement logistics involves the exchange of a wide variety of data and information relating to suppliers and buyers. As the needs of companies become more complex, many disruptive innovations are adopted to support and advance procurement in terms of predictability, transactional automation and proactivity of supplier relationship management. These emerging technologies encompass big data analytics, robotics, internet of things (IoT), blockchain and smart contracts, etc. Therefore, this paper aims to explore the potentialities of these emerging technologies in activities pertaining to procurement and the main organizational barriers that stand against their wide-scale implementation.

Key words:
Procurement, Big Data Analytics, Robotics, Internet of Things, Blockchain, Smart Contracts

INTRODUCTION

Modern supply chains are characterized by their geographic disparity, high complexity, dynamism and uncertainty. Supply chains are expanding and typically span borders, cultures, languages, regulations and continents. The globalized nature of competition combines with increasing customer demands and forces firms to evaluate how they can benefit from emerging information technologies. Many firms are in a constant review process to find better methods to manage their supply chain data and information to gain a competitive advantage. The rapid advancements in digital technologies are reshaping supply chains and are poised to transform how the procurement function delivers value [1] .

Procurement logistics encapsulates the process chain extending from the purchasing of goods through the shipment of the materials to the receiving warehouse [2]. This process is based on the exchange of contractual data and information relating to suppliers products, purchase prices, discounts, raw materials characteristics, delivery terms, and many other

variables. In response to that, there are multiple digital tools and information technologies which are used to support the process of purchasing and companies' overall procurement. [3] emphasized the growing importance of digitization in the field of procurement to handle the virtual information flows and automated transactions. Most companies adopt several forms of core procurement technologies which combine functionality such as spend analytics, e-Sourcing, contract management, and e-Procurement (e-Catalogs, e-Invoicing, etc.) [1]. Even though these technologies are the mainstay of assisting procurement operations, they still undergo radical changes. In this context, 'disruptive innovations' -defined as the changes driven by technology that transforms or displaces existing solutions, processes, etc., across a supply chain or parts of it- are paving the way for more innovative solutions [4]. In doing so, a process re-design is an imperative to render the procurement function as more strategic and open with enhanced accountability, greater transparency and formal reporting capabilities. As a result, this contributes to speeding up the procurement cycle and providing greater access to further opportunities for the firm and its potential suppliers.

In a short span of time, the world has witnessed a succession of major technological shifts. Many of which were driven by the search for lower computing costs, data storage and mining, enhanced forecast accuracy, delivery of reliable data, and analysis of supplier performance, etc. As the needs of firms become more complex, new advancements in technologies have taken place to address the procurement function and advance it in terms of predictability, transactional automation and proactivity of supplier relationship management.

These new emerging technologies are embodied in a simple term called "Industry 4.0". The term represents the convergence of information and communication technologies (ICT) and machinery automation [5]. In parallel, Procurement 4.0 represents the most recent advancements. This concept has been introduced to push communication and collaboration with the network of vendors (outbound procurement), the internal organization (inbound procurement), and the network of customers (outbound procurement). It is based on the use of emerging technologies [5]. To achieve this, several technologies are being deployed to leverage the procurement function such as big data analytics, robotics, internet of things, blockchain, and smart contracts, etc.

New technologies can quickly gain recognition in supply chain management broadly but to a lesser extent in the procurement function. Why is this? We seek to elucidate the potential impact of these emerging technologies when viewed as 'disruptive innovations' in the procurement function. We analyze the extent that these technologies may re-shape the procurement process and support organizational efficiency, effectiveness and profitability. These technological breakthroughs are worthy of closer attention because of the potential impact that the procurement function has on overall business performance. For example, digitalization and automation have been proven to be significantly beneficial especially for increasing efficiency in companies' procurement processes [1] and in coping with the demands of global interconnectivity.

1   THE NEW TECHNOLOGIES IN PROCUREMENT

The procurement function has changed considerably and evolved during the last ten years. This evolution started from the digitization of procurement activities wherein the main advantage of electronic procurement (or e-procurement) is to increase the efficiency of different tasks pertaining to procurement. That is, there is a shift from the traditional process which is supported by a system which collects all information and activities in connection with procurement and therefore creates a "one-to-one" communication between buyer and supplier [6]. As stated by [7], digitization has brought many possibilities for collecting

information on a digital platform which can be accessed, shared and processed in a visible manner with all supply chain partners. This creates a new operating model which is real-time and has 'many-to-many communications capabilities. It makes it possible to rapidly create networks which incorporate the entire production processes and integrate ICT systems at different stages of the business planning process, including inbound procurement, outbound procurement, production, marketing and between different organization (i.e., value networks) [5]. This is justified by the fact that the industrial buying process comprises of series of complex, interdependent actions that includes recognition of a need, development of a technical specification, supplier evaluation and final purchase decision [8]. Moreover, the products and services procured within an organization might exceed 80 per cent of its overall costs which reflect the necessity for companies to drive their procurement department for innovation and contribution toward the value chain [9]. Procurement is no longer a set of straightforward and simple steps. It takes into account many potential factors contributing to the complexity. For instance, timeline and duration, human resources involved in the process and decision making, the number of suppliers contacted during the search process, negotiating tactics, business risk, the composition of the decision making unit, post-purchase evaluation which may reshape future direction [10].

Currently, there is an uncertainty surrounding procurement decisions due to the large amount of information at the disposition of the firm [11]. This information is the backbone of the procurement process and consists of communications (i.e., obtaining, retrieving, analyzing and distributing information relevant to a purchasing decision) and transactions (i.e., activities related directly to the completion of the actual purchase) [12]. With the evolution of information technologies, firms are being forced to innovate in order to mitigate procurement risks and ensure efficiency. This implies that new emerging technologies have to be deployed to support and streamline the interactions between firms and their suppliers.

1.1 Big Data Analytics

Firms create huge volumes of data which is often stored in data siloes by department or by function. This phenomenon is defined by the term Big Data. When it's unused or untapped to extract business insights and value, its referred to as 'dark data' [13]. Firms cannot extract value and insights if the data remains unstructured in siloes. At its core, the concept of big data aims at improving a firms capabilities and speed in decision making. Valuable data can be extracted to help improve many areas of a business including business processes, manage people development, improve capacity planning and optimize supply networks etc. [14]. Big data involves a range of technologies that enable the management, structuring and usage of data in various ways including the processing of larger volumes of data in a shorter time period and with high precision [4].
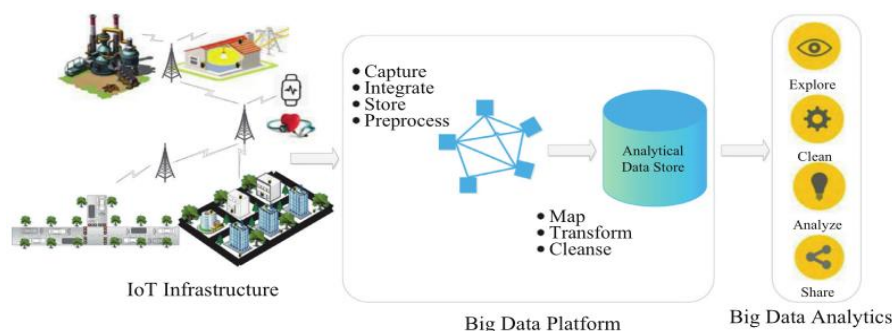

Fig.1 Big Data Analytics
Source: [15]

Procurement organizations operate in various countries and span across geographical boundaries. Local and specific needs of the firms procurement functions has resulted in sporadic IT automation and non-interoperable systems that hinders visibility of data and information behind procurement decisions and transactions. To enable decision makers in procurement to access and utilize large volumes of historical purchasing transactions contracts, pricing information, and supplier performance attributes, big data along with analytics are recognized as important future solutions in procurement [16]. These powerful tools allow firms to turn the unstructured data into an organizational 'gold mine' of insightful information. The many benefits include improved operational planning and decision making, enhanced forecasting capabilities, reduces lead times in certain processes. Essentially big data tools can help to unlock the hidden value within the firms procurement function. Not only that, vendors and supplier firms could improve the design and performance of their components if rapid feedback on product performance was shared more readily, or in real-time. Besides, predictive information, about where and when to expect the next defect provides an opportunity to optimize maintenance services across business operations and the schedule the availability of spare parts [5]. Through the appropriate usage of these technologies, both firms (buyers) and vendors (suppliers) establish a 'win-win' relationship. This may assist in delivering improvements in the networks effectiveness, efficiency and agility.

The shift from supply chain to a value chain network is embodied in the evolution of procurement 4.0. It represents the use of computer-based processes or the organizational cybernetics (i.e., the set of computers used in a data center or propagated within the organization). These intelligent machines and applications helps to optimize the procurement processes in smart factories through the share of near-perfect and real-time information between all the supply chain partners. The adoption of cybernetics in procurement provides a secured and protected platform for managing instantly all orders from customers and to vendors.

1.2 Automatization and Robotics

Currently, robotics and automatization of mechanical processes and activities are regarded as one of the future development possibilities. These leading-edge technologies have the potential to accelerate existing procurement tools by automatizing transactional processes while increasing the accuracy and urging the procurement function managers to concentrate on related strategic problems. Aside from this, the combined usage of robotics along with artificial intelligence (AI) and machine learning (ML) clears the way for significant contributions to the field of procurement in supply chain management. In fact, cognitive computing- defined as a technological platform to mimic and stimulate the thought processes of humans- and artificial intelligence will enable procurement managers to rapidly categorize unstructured spend, cost, contract, and supplier's data (e.g., accounts payable, prices, payment terms, etc.). In doing so, intelligent content extraction tools using the techniques of Optimal Character Recognition (OCR) and learning algorithms allow reading of unstructured documents such as PDFs of contracts, specification drawings, and Bills of Material. The tools are more efficient and can extract critical pieces of data like pricing tables, payment terms, and termination clauses that would take longer to assemble with traditional technologies [1].
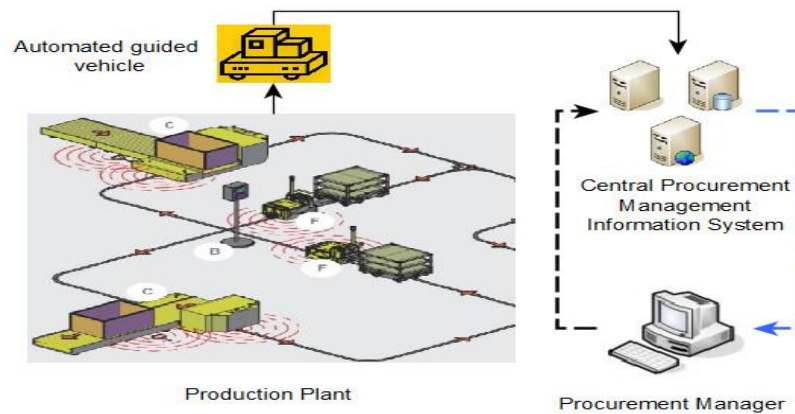
Fig.2 *Supporting Procurement Function with Robotics (e.g., AGV)*
Source: Authors

For instance, as shown in figure 2, the use of automated guided vehicles inside the production plant can support the procurement function by enabling a high resolution and near-to-perfect information visibility over the inbound and outbound procurement. Besides, the needs of processing machines will be synchronized with the material warehouse avoiding breakdowns in the production process or stockouts and related costs. This suggests that these technologies will evolve to a pull-based approach and quickly process a purchase order if stock levels of raw materials reach their reorder level.

1.3. The Internet of Things (IoT)

The internet of things (IoT) is a fast-growing segment of sensing and data collection devices that may disrupts areas of supply chain management. IoT brings further incremental change to business and consumers alike via connections among physical objects [17]. The IoT comprises the use of sensors, actuators, and data communication technology built into physical objects (e.g., various types of RFID tags including environment sensing tags, wireless sensor networks, GPS, etc.) that assist in identifying physical objects, track and trace, coordinating or controlling their movement across the internet [18]. These technologies generate data that will be gathered, routed through internet-based cloud storage and subsequently analyzed by the concerned information system. In doing so, the volume of available information necessary for decision-making process increases substantially. As supported by previous research studies, various technology applications empower companies to process huge amounts of data efficiently [19]. Furthermore, IoT technologies could support the procurement function by reducing the size and the complexity of the procurement center. Certain procurement activities could access and utilize the data gathered via sensors. For example, in monitoring the raw materials consumed by production machine, they could compare and balance the requirements and timing for raw material replenishment with the actual performance capacity and throughput of production equipment. In addition to this, these devices can trail the movement of goods and inventory levels for reordering, and permit audit tracking during the site visits [1]. As a result, the coordination is taken to an unprecedented level allowing purchasing and other functions to receive an engineer's report and feedback to the procurement department in real time, fast, and a concise manner. Moreover, using a GPS device and sensor inputs for products in transit, purchasing manager would gain access to the location of the shipment, as well as its condition (i.e. temperature, humidity etc.) [12]. Thus, this straightforward accessibility allows the company procurement

managers to stay tuned and harmonized with suppliers and reduce risk for a business. The contribution of IoT technologies may help to reduce potential conflicts within the procurement function and improve communication internally and cross departments. The transparency and visibility of the gathered data from the sensors embedded in stock keeping units, totes carrying raw or processed materials or in consumer products helps to reduce the risk of divergent viewpoints and to reach a harmonized position in the purchasing discussion [12].

Overall, the application of IoT could become an incentive to drive changes in the procurement function as well as in its underlying processes.
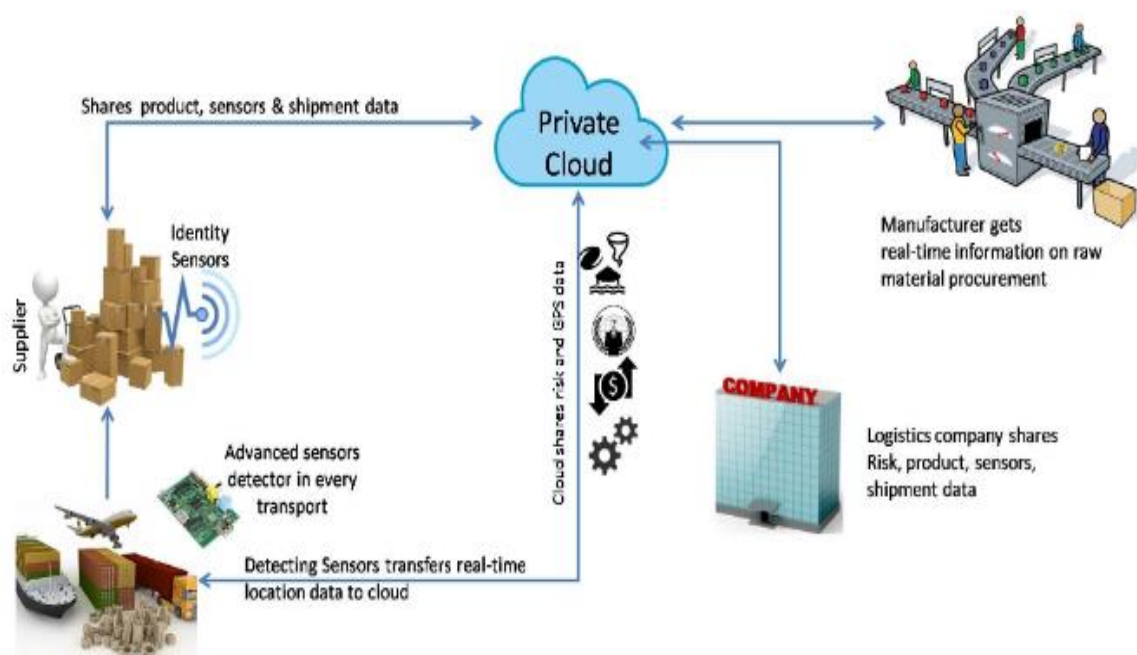

Fig.3 *Typical IoT structure in supply chain*
Source: [20]

1.4. Blockchain Technology

A blockchain is an open, decentralized, and distributed digital ledger that is used to create a trusted peer-to-peer network for exchanging information, value, and assets across many computers (i.e., nodes). A blockchain records and encrypts transactions which are immutable, time-stamped, and shared between the involved partners. These transactions are grouped in a bundle termed as a block in a logical and chronological order. Aside from being very well-known for its bitcoin use case, blockchain opens up additional opportunities to drive increased integrity. For example, usage of smart contracts helps to automate certain procurement activities. It should be noted that the configured blockchain used in the Bitcoin use case had three main components, smart contracts, cryptography and distributed ledger technology (DLT). Academics have noted that smart contracts pre-dates Bictoin/Blockchain by 12-years while cryptography and DLT have been around for thirty plus years albeit that DLT had a centralized control authority [21]. Ultimately, a blockchain can be viewed as a configuration of multiple technologies, tools and methods that address a particular problem.

One of the main important premises of blockchain in procurement is that it allows the different supply chain stakeholders involved in the procurement processes to access an immutable, secured and shared database. Having been registered under one platform, companies can resort to the accumulated data associated with the suppliers' portfolios, the services level agreements, and complaints. Besides, there are seamless benefits that can be achieved in the procurement process using blockchain technology.
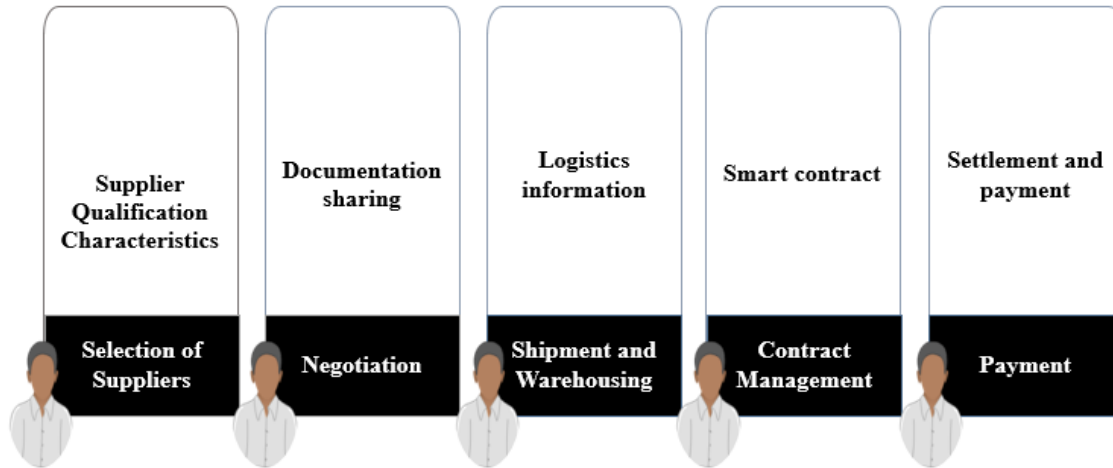

Fig.4 *Leveraging Procurement Process with Blockchain Technology*
Source: Authors based on [5]

A blockchain can help to streamline the procurement process from the selection of suppliers, to the receipt of goods and through to the release of payments. Blockchain can be used to support the company's decision making regarding the supplier selection. That is to say, procurement managers will lean on the blockchain backlog to gain an insight into the suppliers' identity, reputation and past performance, thus limiting risks associated with the acquisition from that vendor [5].

More importantly, blockchain radically changes the modus operandi of implementing digitization into supply chains and creating a "system of record" for data [4]. In traditional supply chains, companies typically capture data on batches of product using a combination of systems and manual paper trails [22]. That is, paper-based system that passes the information along with the products or commodities. This is often compliant with the regulatory requirement for 1-up/1-down traceability in the food and consumer good sectors as an example. In doing so, whenever goods and related documentation (e.g., bills of lading or ship notification) pass from one actor in the supply chain to another, these documents are at risk of counterfeiting, adulteration or theft [23]. In addressing these issues, a configured blockchain helps to facilitate and secure the exchange of sourcing documents, warranties, product assurances (i.e. organic, kosher, halal etc.) and related specifications as immutable, time-stamped, certified and accessible to the interested entities. However, all data inputs into a blockchain record must be verified to mitigate the risk of 'garbage-in, garbage-out'.

By way of illustration, Safeshare is a UK-based company which provides advanced underwriting through the use of blockchain technology to confirm the obligation counterparties [5]. This solution brings about the fast and flexible delivery services of a product at a reasonable cost. Another example of a blockchain being leveraged is in the procurement process. Here, the digitization of contracts, certificates, and vendor quotes can be recorded and accessed rapidly when required. In doing so, the irrevocability and immutability of a blockchain record helps the firm to rapidly access and assess the vendors' qualifications which, in turn, reduces the risk of complaints or disputes from suppliers. A blockchain can support the management of shipments of finished goods inventory. Every party refers to the

same digital register and ensures control of the existence and verification of completeness of shipping documents [5]. It would be also easier and faster to retrieve all data related to the order to- receipt processes. With regard to contract management, the adoption of blockchain in the automation of contracts allows a reduction in administration costs for reconciliation and error [5]. The enforceability of contracts established under a configured blockchain could transfer the ownership of products and services from one party to another. The data and information could be used as an audit trail to verify whether the terms specified in contracts were complied with. Concerning the payment and settlement of the purchased products and services, a blockchain configuration could extend to ensure secure payment between the trading parties with reduced transaction fees. This is due to the fact that blockchain facilitates the transfer and receipt of payment from one party to another without the intervention of a 'middleman' such as a financial institution and mitigates the risk of double spending through the usage of peer to peer network [24].

1.5. Smart Contracts

Some applications of blockchain technology introduce the concept of "smart contracts" [25] which predated bitcoin's usage of a blockchain by more than a decade [21]. Smart contracts are a key component of a blockchain [26] and the concept was first coined and introduced by Nick Szabo in 1994. Szabo defined it as "a computerized transaction protocol that executes the terms of a contract" [25]. Furthermore, he suggests that contractual clauses (e.g., collateral, bonding, and loans terms etc.) should be translated into software code and automated programs within a blockchain would execute a transaction when certain conditions are met. Simply, they are considered as scripts stored on the blockchain to perform certain actions such as the release of funds, the transfer of information, and the purchase of products...etc. when certain conditions are met [27].

From the procurement perspective, smart contracts constitute of business logic that is related to any purchasing transactions. They include members' terms for the business that occurs within their network. They automate the transaction processes beyond the corporate technology boundaries of the company in a secure, trusted and decentralized manner. For instance, the delivery of cargo, shipments or containers of goods and products might be well-suited for the implementation of smart contracts. To counter the risk of any potential loss, a smart contract can be the solution to ensure that the payment by a company will be only released if the logistics service providers confirm the delivery of raw materials in a proper manner and according to the predefined requirements [25].

2 THE CHALLENGES OF NEW PROCUREMENT-ENABLED TECHNOLOGIES

2.1 Technological Immaturity

New emerging technologies could play an important role in dealing with the ongoing evolution of the procurement function with a global context. Any organization who adopts innovative, digital solutions can gain a competitive position while driving enhanced transparency and reducing risk. Nevertheless, most of these cutting-edge technologies are in proof of concept stage of development. Some exceptions include the three key components of Bitcoin's blockchain, namely cryptography, distributed ledger (DLT) and smart contracts. The former two are widely used for over thirty-years (DLT's were traditionally centralized with a control authority function) and the latter is widely used in banking and insurance to automate processes such as loans and repayments etc. [21]. IoT is also widely used across industries and

gaining traction with applications such as temperature sensing and monitoring of in-transit perishables such as fresh produce or meats. Temperature tolerances can be embedded into a smart contract as a pre-condition of incoming inspection acceptance of a shipment for example.

Progress within the traditional procurement function can be slow to gain traction. For example, there can be varying levels of resistance to change and a reluctance to shift away from the existing systems, especially when investments create structural change in business processes.

Moreover, the technological awareness is still insufficient, and more dissemination should take place to promote procurement-enabling technologies. Therefore, employees should be open-minded for the entire fourth industrial revolution and receptive to opportunities raised by these disruptive innovations [6].

2.2 Infrastructure and High Implementation Costs

In order for these new paradigms to be adopted in the procurement function, the engagement across the functions in the organization is necessary. Similarly, suppliers and manufacturers must be willing to adopt the technology. The cultural transformation brought by these new technologies to enhance the administration and procurement activities should be facilitated. Besides, internet connectivity and digital literacy are required for the potential adoption of these technologies to assist the procurement function since the most significant operational risks and challenges are mainly due to insufficient understanding of the functioning of these technologies. Some technologies rely heavily on the extensive use of digital tools which require the development of several kinds of infrastructure, or infostructures. A necessary level of know-how and expertise should be maintained to harness new technologies and to facilitate their adoption on a sustained basis.
Although these technologies may contribute to the reduction of transaction time and costs by streamlining the procurement processes, the unknown capital and operational costs are still deterrent for many businesses to adopt these technologies [28].

3   CONCLUSIONS

Undoubtedly, there is a growing pace of technological innovations disrupting supply chain and procurement activities. However, as experts advice, innovations such as blockchains should be viewed as foundational and not disruptive. In other words, it will become an embedded foundational layer for business, but it will take time to implement [29]. Procurement managers should cope with these changes and evolution of the procurement function. While these technologies are not considered as a panacea or silver bullet for all the problems and issues pertaining to procurement activities, they show a wide range of new promising possibilities and benefits taken to an unprecedented level and never experienced in the procurement field before. As noted earlier, a blockchain for example should not be viewed as a technology per-se but as a configuration of multiple technologies, tools and methods that addresses a use case or business problem. In this context, a particular blockchain can be viewed like a recipe for baking a cake. The 'recipe' is the ingredients, tools, methods and instructions and the cake being the use case. Hence, the 'recipe' will vary depending on the use case or business problem a business aims to solve.

From one hand, these technologies will consolidate and automate the procurement activities allowing a higher level of transaction automation, efficiency, and effectiveness. They empower more disintermediation processes efficiencies and collaboration between the

firm and its suppliers. On the other hand, the technical and economic feasibility of adopting new procurement-enabling technologies is still very challenging and there is yet some uncertainty on their prospects in the procurement use case context. These disruptive innovations imply transformations that are not easy to assimilate. Procurement 4.0 is deemed to be a revolution in e-procurement. Big data analytics, artificial intelligence, robotics, internet of things, blockchain and smart contracts are the main examples of future technological implementations in procurement. New disruptive innovation will continue to surpass our imagination in the near future.

Further research is needed to evaluate the cost-benefit analysis, the technical and economic feasibility of each technology in the procurement process as well as in other organizational functions.

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