



This document is the original author manuscript of a paper submitted to an IFIP conference proceedings or other IFIP publication by Springer Nature. As such, there may be some differences in the official published version of the paper. Such differences, if any, are usually due to reformatting during preparation for publication or minor corrections made by the author(s) during final proofreading of the publication manuscript.

Procurement 4.0: A systematic review of its technological evolution

Bueno, Robson Elias ¹[0000-0003-3633-8903], Almeida dos Santos, H. ²[0000-0003-0828-9630], Junior Freitas, Moacir de ³[0000-0002-0720-5522], Toloi, Rodrigo Carlo ⁴[0000-0001-6320-8894], Gonçalves, Rodrigo Franco ⁵[0000-0003-2206-3136].

^{1, 2, 3, 4, 5} Graduate Studies in Production Engineering, University Paulista, Sao Paulo, Brazil
robsonebueno@gmail.com

Abstract. Industry 4.0 is significantly transforming the traditional way of managing supply chains. However, Industry 4.0 tools can be expensive and not affordable and can be implemented in a variety of ways. Therefore, the benefits of implementing these tools should be clarified before investing in digitizing the Procurement process. The objective of the work is to present the dimensions (Competencies, Management, Partnerships, Processes, Systems/Technologies, and Sustainability) and the tools of Ind4.0 motivating the trends of evolution in the procurement area in the face of these changes in technologies and digital transformation. Despite the importance of this issue, few studies have attempted to address the effects of Ind4.0, technologies, and intelligent systems in procurement. To fill this gap, in the applications of Ind4.0 tools a conceptual model was developed to classify different value propositions provided by the different applications of Ind4.0 tools in the internal and external processes of the area. Finally, the results conclude that the six dimensions proposed in the conceptual model can provide a better understanding of the Procurement area, demonstrating the trends of the implementation of Ind4.0 tools related to different activities, presented by the literature authors.

Keywords: Industry 4.0; Procurement 4.0; value proposition; supply chain; digitization

1 Introduction

The new industrial revolution is beginning and is changing the way we live, work and relate to each other [1]. To meet this new requirement, manufacturing and all processes of companies will need to adapt [2]. The importance of developing and managing innovative procurement *strategies* is clear [3]. From a historical perspective, procurement has undergone major transitions, especially in recent decades, in the sense that organizations have had to deal with pressures related to cost reduction and increased profits [4].

According to Batran et al. (2017) [5], the reality is that the pace of change and the scale of challenges we face require a new approach to how we do business. Change is continuous: Procurement 4.0 must be able to easily adapt and take advantage of emerging opportunities. It is also an integral and essential component of a larger system within a given organization. Procurement 4.0 can improve supply chain performance by adding values and improving visibility and resiliency. The idea of Procurement 4.0 and the values aggregated by this concept is a new subject that is rarely addressed and suffers from great uncertainty due to the involvement of complex supply chain activities and multicriteria decision-making [6]. In terms of processes, problems, and solutions in defining how procurement can add value to customers, inside and outside an organization;

and how it can help manage relationships, improve processes, and better resource management, both internally and with partners [7]. In this sense, the research questions are: How will the process be different from the current Procurement system to Procurement 4.0? What technologies can be used? What is the tendency of Procurement evolution? The paper is conceptual to achieve the goal of organizing the literature through a systematic review and evaluating the process, technologies, and trends of the evolution of Procurement to Procurement 4.0.

For this, we carried out a systematic review of the literature and established a conceptual frame (table 1) of Procurement evolution, technologies, and tendencies of Procurement 4.0.

The paper is organized as follows: Section 2 presents the background of the review of Industry 4.0 and Procurement concepts; section 3 presents the systematic review method, used to organize and classify the literature into six dimensions; Section 4 presents the results of literature research on Procurement, technologies of industry 4.0 and the respective references; Section 5 presents the discussion and conclusions about the evolution of Procurement to Procurement 4.0, emphasizing process improvements.

2 Theoretical Review

2.1 Industry 4.0

As a way to contextualize the *Procurement 4.0 scenario*, we raise information about industry 4.0, digital technologies, and the structure of procurement. Germany brings a new paradigm of industrial production to the world, with the appropriation of digital technology disseminated on the Internet and executed by the Elements Internet of Things [8]. Bonilla et al., (2018) [9], common that due to its unique characteristics, the goal of Industry 4.0 is to increase productivity and customization that are achieved through the flexibilization of manufacturing and decentralization through the digitization and integration of the information network, allowing the real-time monitoring and control.

2.2 Procurement and Procurement 4.0

Procurement can be defined as the "business management function that ensures the identification, supply, access, and management of external resources that an organization needs or may need to meet its strategic objectives" [10]. Procurement is a function of procurement of products and services, especially for commercial purposes. Among them are supplier selection, payment terms, contract negotiation, regulatory compliance, analysis, and outsourcing [11]. This is possible because Procurement has strategic know-how about suppliers and their markets, deep expertise in the products and services purchased, and the alternatives on offer, including emerging innovations [12].

Procurement 4.0 connects the organization with its suppliers and enables dynamic co-operation and coordination of the procurement process [13]. Procurement 4.0 includes a range of processes and changes within a company as they work to develop new procurement value propositions and incorporate supplier management into purchasing software [14]. According to current literature, Procurement 4.0 can be understood as an intelligent system capable of autonomously detecting material demand, generating your

order, and even transmitting the order to the supplier without the need for human involvement [15]. Procurement 4.0 aims to optimize the value provided by the purchasing function [3].

3 Method

First, we selected the Google Scholar, Scopus, and Web of Science databases. In the second step, we select the keyword applied to collect related articles. The keyword "procurement 4.0" is new to academic literature and the resulting terminology for the new synonym for I4.0 and Supply Chain 4.0. The illustration presents the methodology in figure 1.

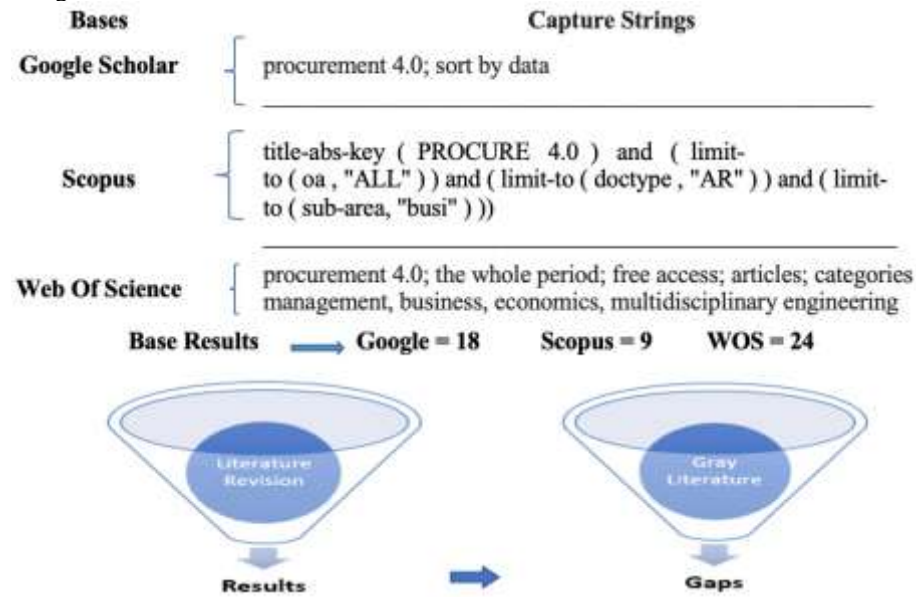


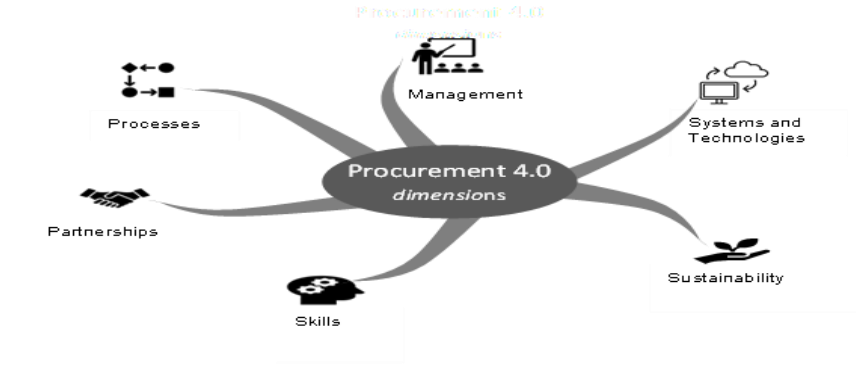
Fig. 1. Illustration of the methodology used in this article.

Instead of covering a rigid systematic review, we conducted a review at different levels, looking for text representative of technologies within the Procurement approach, showing a current or potential use in the construction of Procurement 4.0. After the analysis of the articles, a gap was presented in the literature presented, of the term Procurement 4.0 for still being reduced publications, to repair it was used an approach in the gray literature [36], specialized scientific journals and management reports were used to extract technologies applied in various forms and levels of intervention that help to manage this change. Public Procurement cases were discarded because they did not belong to the scope of the search.

For example, Henke and Schulte [16] argue that the acquisition of partners and the interface layer of production solutions offer the opportunity to position itself as a key factor for the development of industry 4.0, postulating several opportunities. Contributing to this reasoning, Bueno et al. [17] present six essential dimensions for the implementation of Procurement 4.0 that will require a mutation in companies, and their Strategic, Tactical, and Operational planning: Competencies, Management, Partnerships,

Processes, Systems / Technologies, and Sustainability. Figure 2: Illustrates the established dimensions of Procurement 4.0.

Fig. 2: Dimensions for Procurement 4.0, based on Bueno et al. [17]



4 Results

The intention advocated in this article was to address the six dimensions and technologies of industry 4.0, to present the due rupture[3] of Procurement for Procurement 4.0. The introduction of 4.0 technologies will mean developing new value propositions, meeting new business needs, and integrating data between roles and value chains. Procurement 4.0 include forming service level agreements with suppliers, maintaining the procurement intranet site, frequent design reviews and stakeholder satisfaction surveys, and identifying and implementing opportunities for improvement [15]. Table 1 presents the procurement break for version 4.0.

Table 1: Evolution of Procurement technologies

Dimensions	Industry 4.0 Technologies	Transition in Procurement Operations	Tendences	Authors
Skills	Cloud Computing, Internet of Things (IoT), Blockchain Technology, Cybersecurity, Big Data Analytics, Advanced Robotics, Virtual/Augmented Reality, 3D Printing, and Additive Manufacturing.	Reduced team workload	Multi talent profiles.	[18]
		Creating synergies	Consultants	[19]
			Data Analysts (Descriptive analytics to cognitive analytics).	[20]
		Communication	Strategic with the business.	[21]
Management	Cloud Computing, Internet of Things (IoT), Blockchain Technology, Cybersecurity, Big Data Analytics, Advanced Robotics, Virtual/Augmented Reality, 3D Printing, and Additive Manufacturing.	Strategic Positioning	Relationship management and strategic thinking.	[22]
		Strategic Positioning	Mastery of proprietary technology.	[18]
		Creation of new business networks	Third party independence.	[19]
		Cost reduction	Process and data integration.	[5]
			Cost of acquisition and supplier selection.	[24]
Partnerships	Cloud Computing, Internet of Things (IoT), Internet of Services (Ios),	Supplier Administration	Higher Profits.	[20]
			Greater Autonomy.	[21]
			Creation of new business networks. Use of blockchains for contract validation.	[18]

	Blockchain Technology, Cybersecurity, Big Data Analytics, Advanced Robotics, Virtual/Augmented Reality, 3D Printing, and Additive Manufacturing		More agile communication with customers and suppliers.	[19]
		More transparency in the supply chain	Increased transparency of data and information.	[20]
		Proactive Response	Early issuance of outage notices.	[23]
			Strategic Partners.	[5]
		Risk management	Improved evaluation of customer and supplier data.	[21]
Processes	Cloud Computing, Internet of Things (IoT), Internet of Services (Ios), Artificial Intelligence, Simulation, Blockchain Technology, Cybersecurity, Cyber Physical Systems, Big Data Analytics, Advanced Robotics, Virtual/Augmented Reality, 3D Printing, and Additive Manufacturing .		Digitization of processes and procedures.	[18]
		Demand analysis	Greater efficiency, flexibility and fast reaction time.	[19]
		Information flow	Automated allows perfect coordination, saving coordination costs.	[13]
		Process standardization	Decreased travel costs and increased speed in decision making.	[20]
		Fast reaction times	Better connections with global supplier network.	[21]
Systems and Technologies	Cloud Computing, Internet of Things (IoT), Internet of Services (Ios), Blockchain Technology, Simulation, Cyber Security, Big Data Analytics, Advanced Robotics, Virtual/Augmented Reality, 3D Printing, Additive Manufacturing, and Artificial Intelligence.	Improved data quality (greater significance due to information and not just data).	Real-time availability of data and information.	[18]
		Real-time availability of data and information.	Improved data availability, fully computerized.	[19]
		Intelligent behavior	Increased transparency of data and information.	
			Autonomous Vehicle Routing, Locating Potential Suppliers, Order Scaling, and Lot Storage.	[25], [26]
		Database security	Data sharing, visibility and transparency promotes trust.	[15]
Sustainability	Cloud Computing, Internet of Things (IoT), Blockchain Technology, Cybersecurity, Big Data Analytics, Advanced Robotics, Virtual/Augmented Reality, 3D Printing, and Additive Manufacturing.	Fully automated information flow.	Improved evaluation of customer and supplier data.	[21]
		Reduction of costs associated with waste management.	Socially responsible shopping.	[27]
		Sustainable shopping	Cloud data associated with sustainability, such as carbon footprint (environmental) and waste disposal costs (economic) and social aspects.	[28]
		Corporate image	Economic, environmental and social behavior depends heavily on your supply chain.	[30]

	Sustainable Production	Flexibility in production volumes.	[19]
	Facilitates compliance with legal requirements.	Acquisitions covering environmental, economic and social (TBL) elements.	[30]
		Incorporation of new technologies.	[20]
	It demonstrates the organization's commitment to a sustainability and social responsibility policy.	Perceived Costs/Benefits: Sustainable products play a prominent role in sustainable procurement.	[31]

5 Discussion and Conclusions

Despite the emerging literature on this subject, it is notorious that there is a lack of comprehensive and systematic structures, strategies, and approaches for the implementation of Industry 4.0 concepts in the Procurement processes. The literature has in common that the described procurement process was initiated not by a single technology, but by the interaction of various technologies and solutions whose effects created new modes of production, but also influenced organizations, the environment, and social functions, in accordance with [32].

Procurement is no longer a personality-centered function, where professionals in the area manage everything on their own, using only the knowledge they have acquired over time. Based on the research of the literature presented, the table presented how Industry 4.0 technologies will change the way the Procurement process works and what are the trends of this evolution. Procurement 4.0 will transform the operation of the Supply Chain. Applicable technologies represented substantial values and aggregated values consist of improving performance in operations associated with purchasing management in supply chains, such as pricing, supplier selection, evaluation, cost-benefit, data collection, and analysis. The presence of digital integration is transforming business processes, both internal and external, with the implementation of Ind.4.0 technologies. Processes and data are increasingly transparent and accessible, intelligence in Procurement 4.0 requires a transformation in the organization in the six dimensions presented.

The adoption of Procurement 4.0 results in autonomy, flexibility, and transparency of operations associated with purchasing management to optimize pricing decisions, supplier management, and purchasing management, or to develop sustainability and data sharing security [33,34]. Given the issues related to the application of Industry 4.0 technologies in Procurement and compared with the existing literature in the area, this article focuses not only on technological trends but proposes a vision of Procurement evolution and tendencies. However, our reviewed literature does not find a clear concept of Procurement 4.0. Future studies can focus on a conceptual model of Procurement 4.0.

References

1. Kagermann, H.; Anderl R.; Gausemeier J.; Schuh G; Wahlster W. (Eds.) (2016). ("the digital world") Industrie 4.0 in a Global Context: Strategies for Cooperating with International Partners. Munich: Herbert Utz Verlag.
2. Chiang, W. C. (2016). Development of a lean non-adjusting setup system – A case study of

- Aluminum rims production. Christian University; Chung Yuan, Taiwan, 2016. 104p.
3. Nicoletti B. (2020). Procurement 4.0 and the Fourth Industrial Revolution. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-35979-9_1.
 4. Uusitalo, J. (2019). Strategic acquisitions in the face of uncertainty. Master's thesis. University of Jyväskylä, Finland.
 5. Batran, A. et al. (2017). A survival guide in a digital, disruptive world. Frankfurt: Campus.
 6. Bag, S.; Wood, LC; Mangla, SK; Luthra, S. (2020). Procurement 4.0 and its implications for business process performance in an economy circular. *Resource. conservation Recycle*, 152, 104502.
 7. Nicoletti, B. (2017). *Agile Acquisitions. Volume II: Designing and Implementing a Digital Transformation*, Springer International Publishing, London, UK, ISBN 978-3-319-61085-6.
 8. Kagermann, H., Wahlster, W., Helbig, J.B (2013). Securing the future of German manufacturing industry: recommendations for implementing the strategic initiative INDUSTRIE 4.0. German National Academy of Science and Engineering (ACAT- ECH) Technical Report.
 9. Bonilla, SH; Silva, HRO; Terra da Silva, M.; Franco Gonçalves, R.; Sacomano, JB Industry 4.0 and Implications of Sustainability: A Scenario-Based Analysis of Impacts and Challenges. *Sustainability* 2018. 10, 3740. <https://doi.org/10.3390/su10103740>.
 10. Andrew, K. (2005). "The definition of acquisitions", Chartered Institute of Purchasing and Supply, Australia, pp. 1-7.
 11. Chakravarty, Sukriti. (2017). What is the difference between procurement and sourcing? Available at: www.tendersinfo.com/blogs/what-is-the-difference-between-procurement-purchasing-and-sourcing.
 12. Weissbarth, Robert., Geissbauer, Reinhard., Wetzstein, Jurgen; (2016). Procurement 4.0: are you ready for the digital revolution? Available in: <https://www.strategyand.pwc.com/report/procurement-4-digital-revolution>. Access on 20/04/2020.
 13. Glas, A.H., and Kleemann, P.F.C. (2016). "The Impact of Industry 4.0 on Procurement and Supply Management: A Conceptual and Qualitative Analysis", *International Journal of Business and Management Innovation*, Vol. 5 No. 6, pp. 55–66.
 14. PWC Report (2016). Procurement 4.0: Are You Ready for Digital Revolution? Available at <https://www.strategyand.pwc.com/report/procurement-4-digital-revolution>. Accessed on June 25, 2020.
 15. Bienhaus, F., Haddud, A., Bienhaus, F. and Haddud, A. (2018). "Procurement 4.0 : factors influencing the digitization of procurement and supply chains." *Business Process Management Journal*, Vol. 24 No. 4, pp. 965–984.
 16. Henke, M., & Schulte, AT (2015). Einkauf und die 4. Industrielle Revolution, *Beschaffung Aktuell*, 62 (3): 20–21.
 17. Bueno, R E; Freitas Junior, Moacir De; Da Silva, Marco Aurélio; Lombardi, Império; João Victor Bueno. (2021). THE EVOLUTION OF LOGISTICS: PROCUREMENT 4.0. Production engineering [electronic book] : quality management, production, and operations: volume 2 / Ernane Rosa Martins. organizer. Guarujá, SP: Scientific Digital. ISBN 978-65-5360-036-2_DOI 10.37885/978-65-5360-036-2.
 18. Burton, Niul. (2015). Procurement 2025: 10 Challenges that Will Transform Global Sourcing. Disponível em www.industryweek.com/global-sourcing. Acesso em 20/04/2021.
 19. Fraunhofer, IML, (2016). The Digitalization of Procurement. Pilot Study Procurement 4.0 Fraunhofer IML BME. Disponível em: https://www.iml.fraunhofer.de/content/dam/iml/en/documents/OE260/Pilot%20Study_Procurement%204-0_Fraunhofer%20IML_BME.pdf - Acesso em 20/04/2021.
 20. Biazzin, C. (2017). Inteligência em Compras. GV executivo, v.16, n°6, nov/dez. Supply Chain, Operações e Logística • inteligência em compras. Disponível em: <https://biblioteca-digital.fgv.br/article/download>.
 21. CIPS (2019). Digitalization in Procurement and Supply. Disponível em: https://www.cips.org/PageFiles/138071/CIPS_Digitalisation_of_Procurement_WEB.pdf.

Accessed on 02 July 2021

22. Bals, L., Schulze, H., Kelly, S. and Stek, K. (2019). "Journal of Purchasing and Supply Management Purchasing and supply management (PSM) Competencies : Current and future requirements", *Journal of Purchasing and Supply Management*, Elsevier Ltd, Vol. 25 No. 5, p. 100572.
23. Tripathi, Shubham & Gupta, Manish. (2020). A framework for procurement process re-engineering in Industry 4.0. *Business Process Management Journal*. ahead-of-print. 10.1108/BPMJ-07-2020-0321.
24. Klunder, T., Niklas, J. and Steven, M. (2019). "Procurement 4 . 0 : How the digital disruption supports cost-reduction in Procurement," *Production*, Vol. 29, available at: <https://doi.org/10.1590/0103-6513.20180104>.
25. Pomerleau, Da. (2012). *Neural Network Perception for Mobile Robot Guidance*; Springer Science & Business Media: Berlin/Heidelberg, Germany, Volume 239
26. Ciula, G.; D'amico, A.; Brano, VL; Traverso, M. (2019). Application of an optimized artificial intelligence algorithm to assess the heating energy demand of non-residential buildings at a European level. *Energy*, 176, 380-391.
27. Park, H; Stoel, L. (2005). "A model of socially responsible purchasing/supply decision-making processes", *international journal of retail & distribution management*, vol. 33no.4, pp.235-48.
28. Singh, A.; Kumari, S.; Malekpour, H.; Mishra, N. (2018). Big data cloud computing framework for selecting low carbon suppliers in the supply chain beef supply. *J. Clean. Product* 202, 139-149.
29. Xie, G. (2016). "Cooperative strategies for sustainability in a decentralized supply chain with competing suppliers." ("Manufacturer's cooperation strategy of closed-loop supply ...") *Journal of Cleaner Production*, 113, 807-821. <http://dx.doi.org/10.1016/j.jclepro.2015.11.013>.
30. Meehan, Joanne; Bryd, David. (2011). Sustainable procurement practice. *Business strategy and the environment bus. Strat. Env.* 20, 94–106 published online 3 May 2010 in Wiley online library (wileyonlinelibrary.com) DOI: 10.1002/bse.678.
31. Brammer, S.; Walker, H. (2011). Sustainable procurement in the public sector: An international comparative study. *International Journal of Operations and Production Management*. v.31, n.4, p.452-476.
32. Schmidt, R., Möhring, M., Härting, RC, Reichstein, C., Neumaier, P., & Jozinovi Ć, P. (2015). Industry 4.0 potentials for creating smart products: results of empirical research. At the International Conference on Business Information Systems, 16–27. Springer, Cham, Switzerland.
33. Babiceanu, RF; Seker, R. (2016). Big Data and Virtualization for the Fabrication of Cyber-Physical Systems: A Survey of Current Status and Future Perspectives. *To compute. Ind.* 81, 128-137.
34. Fatorachian, H.; Kazemi, H. (2021). Impact of Industry 4.0 on supply chain performance. *Product Plan. To control*, 32, 63-81.
35. Neto, G. T. G., Santos, W. B., Endo, P. T., and Fagundes, R. A. (2019). "Multivocal literature reviews in software engineering: Preliminary findings from a tertiary study." ("Multivocal literature reviews in software engineering ...") In 2019 ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM), volume 2019-Sept pages 1–6. IEEE.
36. Côrtes, Pedro Luiz. The Importance of the Grey Literature Available on the Internet for the Areas of Accounting and Business Administration *Brazilian Journal of Business Management*, vol. 8, no. 20, January-April 2006. pp. 13-22. Álvares Penteado School of Commerce Foundation São Paulo, Brazil.